INSTRUCTIONS

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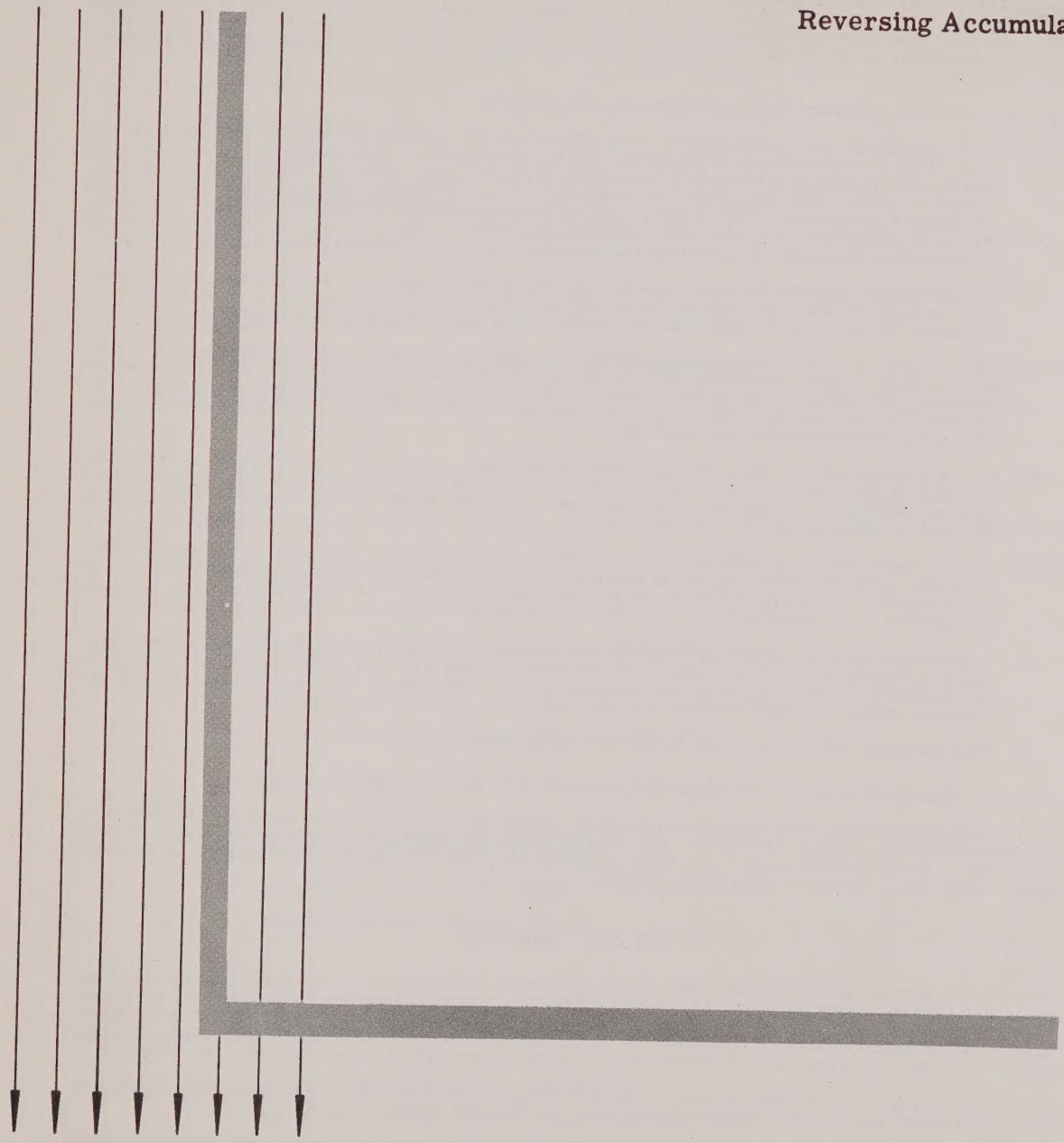
ELECTRONIC INSTRUMENTS DIVISION

of Beckman Instruments, Inc.
composed of the former Berkeley
Division and Offner Operations

Beckman®

INSTRUCTION MANUAL

MODELS
6013A, 6014A, & 6015A
Reversing Accumulators



Beckman® INSTRUMENTS, INC.
ELECTRONIC INSTRUMENTS DIVISION
2200 WRIGHT AVENUE
RICHMOND, CALIFORNIA • 94804
(415) 526-7730; TWX: 910-382-8125

INTERNATIONAL SUBSIDIARIES: Geneva; Munich; Glenrothes, Scotland; Tokyo; Paris; Capetown; London; Mexico City.

PRINTED IN U.S.A.

June 1966

WARRANTY

Instruments sold by Electronic Instruments Division, Beckman Instruments, Inc., (hereafter called "the Company") are warranted only as stated below.

Subject to the exceptions and upon the conditions specified below, the Company agrees to correct, either by repair, or, at its election, by replacement, any defect of material or workmanship which develops within one year after delivery of the instrument to the original purchaser by the Company or by an authorized representative, provided that investigation and factory inspection by the Company discloses that such defect developed under normal and proper use.

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(d) Except as stated above, the Company makes no warranty, express or implied (either in fact or by operation of law), statutory or otherwise; and, except to the extent stated above, the Company shall have no liability under any warranty, express or implied (either in fact or by operation of law), statutory or otherwise.

(e) The Company expressly disclaims any liability to its customers, dealers, and to users of its products, and to any other person or persons for consequential damages of any kind and from any cause whatsoever arising out of or in any way connected with the manufacture, sale, repair, replacement of, or arising out of or in any way connected with the use of any of its products.

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RICHMOND, CALIFORNIA • 94804

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DESCRIPTION

GENERAL

Except as noted in the following paragraphs, all information in the Models 6013, 6014, and 6015 instruction manual applies to the Models 6013A, 6014A, and 6015A instruction manual.

INTRODUCTION

The five-digit front panel edge-lit display has been replaced by a group of five numerical glow-tube indicators (see figure 1). Table 1 gives the specifications of these glow-tubes.

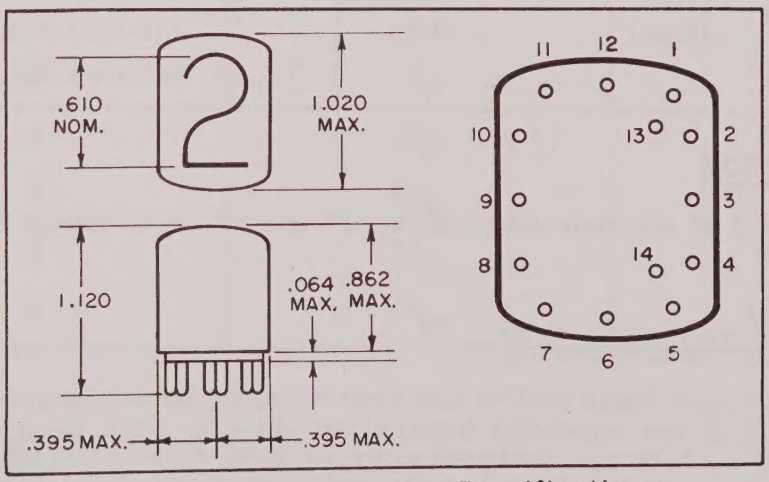


Fig. 1. Glow-Tube Specifications

Table 1. Glow-Tube Specifications

Type	B5991 Ultra Long Life Rectangular
Absolute Ratings	
Ionization Voltage (Max)	170Vdc
Supply Voltage (Min)	170Vdc
Cathode Current (Peak)	3.5 ma
Test Conditions	
Supply Voltage	180Vdc
Series Resistor	8.2 K
Cathode Current (Min)	1.5 ma
(Max)	3.0 ma

PIN CONNECTIONS	
Pin No.	Characters
1	Anode
2	Numeral 0
3	Numeral 9
4	Numeral 8
5	Numeral 7
6	Numeral 6
7	Numeral 5
8	Numeral 4
9	Numeral 3
10	Numeral 2
11	Numeral 1
12	Internal Connection
13	Internal Connection
14	Internal Connection

OPERATION

Figure 2-1 in the appended instruction manual is no longer applicable.

THEORY OF OPERATION

The five count-chain DCU's (decimal counting units) described in paragraph 3.6 of the appended instruction manual, have been replaced by five DCU's which are designed to drive glow-tube indicators. Refer to the Biquinary DCU (Forward-Reverse, With Readout) Schematic Diagram drawing no. D427999.

The basic counting circuitry in these DCU's is the same as that used in the previous DCU's. However, the output from this DCU consists of ten lines in decimal code; each line drives a single cathode in the glow-tube indicator associated with the DCU. These ten lines are derived from the basic counting circuitry via ten buffer amplifiers. Table 2 shows the interconnections between the DCU and the glow-tube indicator. This table replaces figure 3-9 in this instruction manual.

Table 2. DCU to Glow-Tube Interconnections

Glow-Tube Numeral	DCU Pin Number	Glow-Tube Socket Pin Number
0	3_R	2
1	4_R	11
2	5_R	10
3	6_R	9
4	7_R	8
5	8_R	7
6	9_R	6
7	10_R	5
8	11_R	4
9	12_R	12

SERVICING

A change has been made in the power supply; the -32 volt dc supply has been replaced by a +175 volt dc supply, which is used to energize the anodes of the glow-tube indicators.

Figure 2 replaces figure 4-1 in the appended instruction manual; figure 3 replaces figure 4-2 in the appended instruction manual.

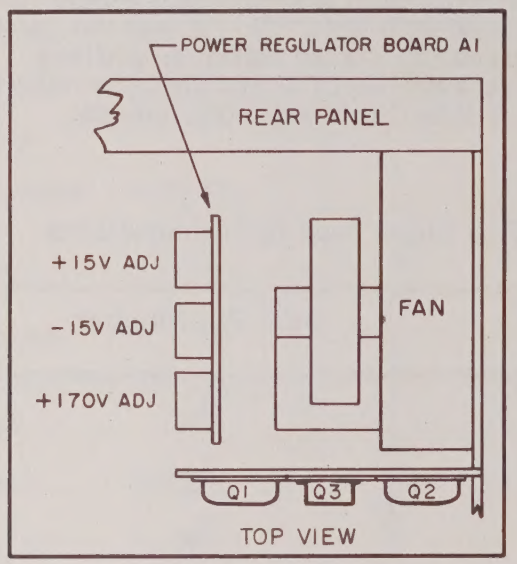


Fig. 2. Location of Power Supply Adjustments

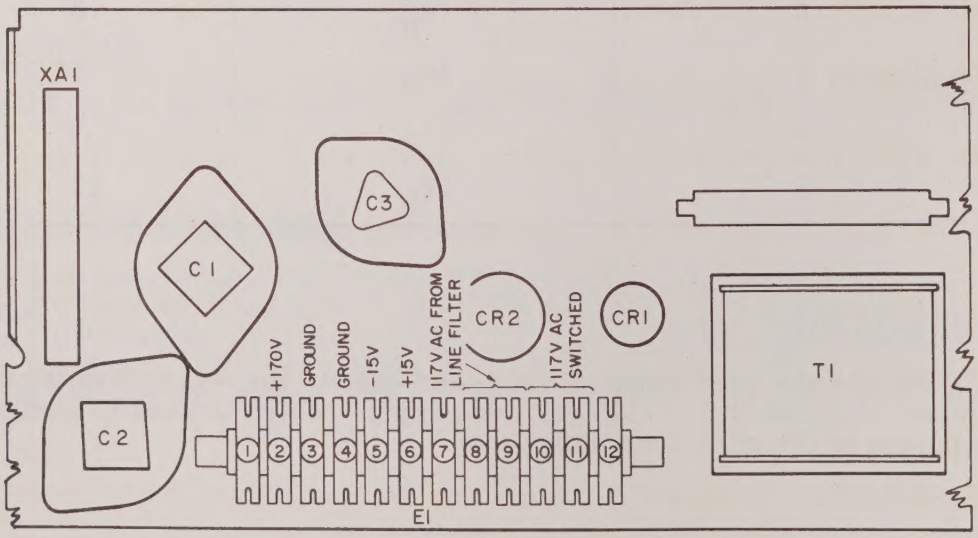


Fig. 3. Power Supply Test Points

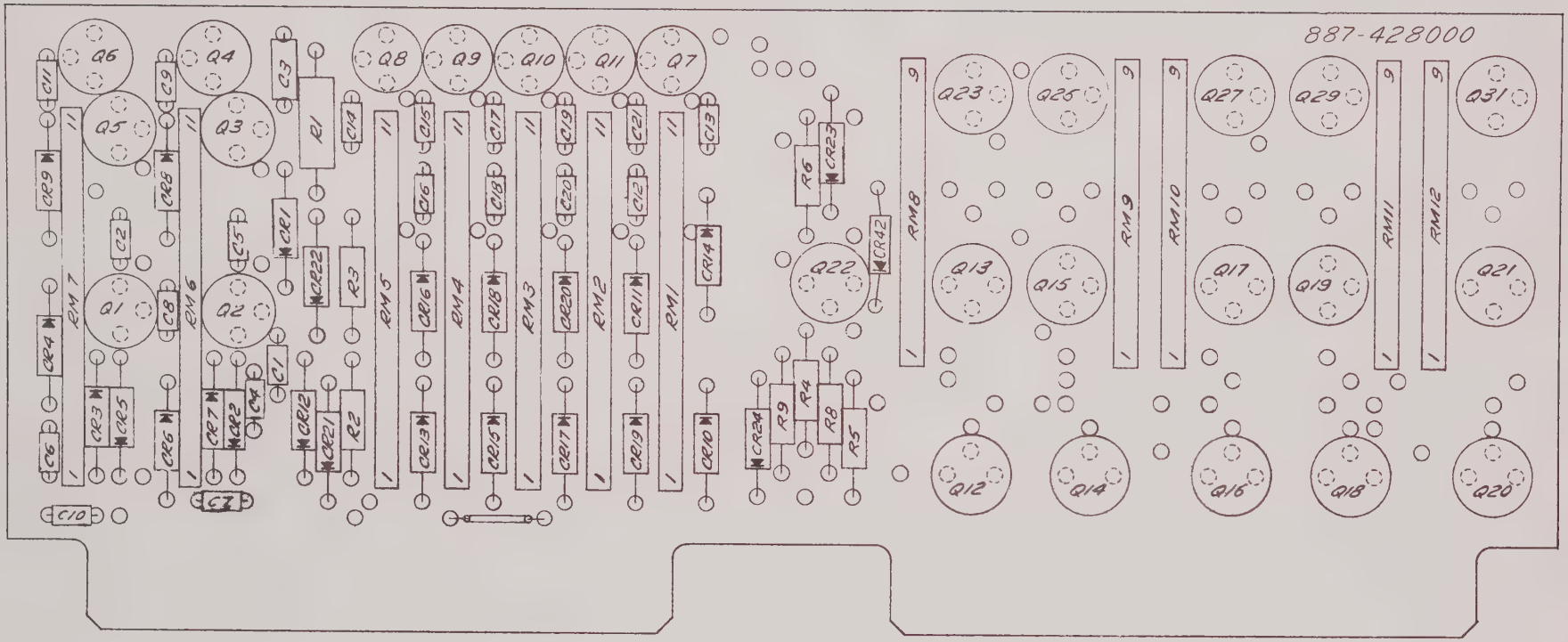
PARTS LIST

Regulator Printed Circuit Board

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Assy.
C1	631-844520	Capacitor, Elect., Tant., 1μf, 35V, ±20%	Kemet K1P35	2
C2		Same as C1		
CR1	755-404593	Diode, Special	Beckman	3
CR2	755-814019	Diode, Zener	P.S.I. 1N754A	1
CR3		Same as CR1		
CR5		Same as CR1		
CR6 & CR7	755-416842	Diode, Special	Beckman	2
CR8	755-814045	Diode, Zener, 1N751A	DBP TN 751A	1
Q1	755-817210	Transistor	Texas Inst. 2N1304	2
Q2	755-836485	Transistor	Texas Inst. 2N2374	2
Q3	755-800398	Transistor, 2N404	G.E.	2
Q4		Same as Q1		
Q5		Same as Q2		
Q6		Same as Q3		
Q7	755-817964	Transistor	P.S.I. 2N1420	1
R1	601-008080	Resistor, F., Comp., 2.2K, 1/2W, 10%	Allen Bradley EB2221	2
R2	601-822327	Resistor, F., Comp., 220Ω, 1/4W, 5%	Allen Bradley CB2215	2
R3	601-812856	Resistor, F., Comp., 2.2K, 1/4W, 10%	Allen Bradley CB2221	2
R4	601-823111	Resistor, F., Comp., 1K, 1/4W, 10%	Allen Bradley CB1021	1
R5	601-822369	Resistor, F., Comp., 680Ω, 1/4W, 5%	Allen Bradley CB6815	1
R6	611-812861	Resistor, Var., W.W., 200Ω	C.T.S. Series 111	2
R7	601-823396	Resistor, F., Comp., 560Ω, 1/4W, 5%	Allen Bradley CB5615	1

Regulator Printed Circuit Board - continued

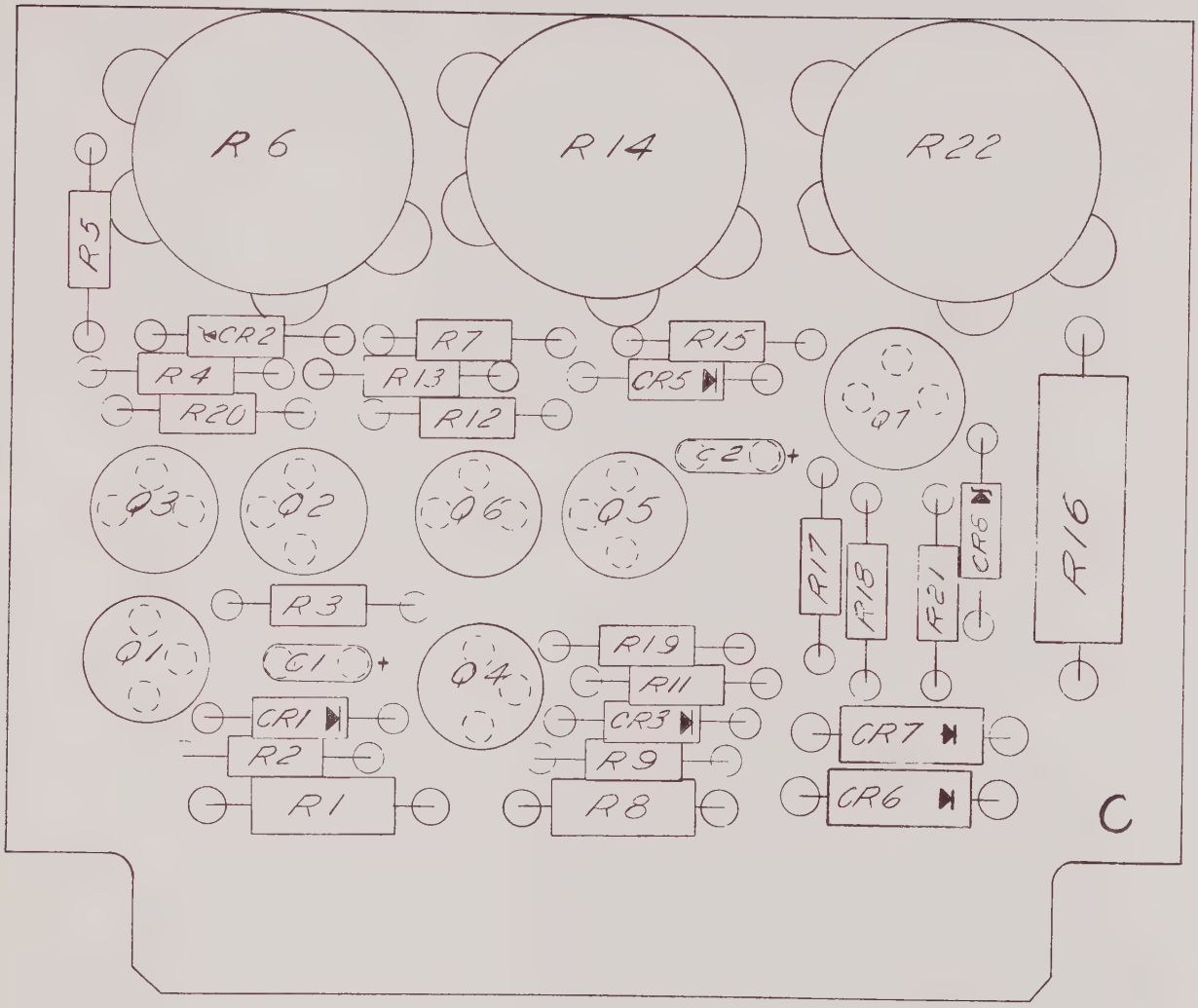
Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Assy.
R8		Same as R1		
R9		Same as R2		
R11		Same as R3		
R12	601-822308	Resistor, F., Comp., 1K, 1/4W, 5%	Allen Bradley CB1025	2
R13	601-822306	Resistor, F., Comp., 820Ω, 1/4W, 5%	Allen Bradley CB8215	2
R14		Same as R6		
R15		Same as R13		
R16	607-844498	Resistor, F., Film, 68K, 1%	IRC MEC-TO	1
R17	607-821212	Resistor, F., Film, 1.96K, 1/8W, 1%	IRC CEA-TO	1
R18	601-822299	Resistor, F., Comp., 6.8K, 1/4W, 5%	Allen Bradley CB6825	1
R19	601-822544	Resistor, F., Comp., 1.8K, 1/4W, 5%	Allen Bradley CB1825	1
R20		Same as R12		
R21	601-822326	Resistor, F., Comp., 1.2K, 1/4W, 5%	Allen Bradley CB1225	1
R22	611-815619	Resistor, V., W.W., 500Ω, 1.5W, 20%	CTS Series 111	1
	864-412958	Transistor Pad	Beckman	7



BI-QUINARY DCU (FWD/REV. w/READOUT) COMPONENT LAYOUT

6013A, 14A, 15A
D42800-Rev. C
June 1966

Beckman

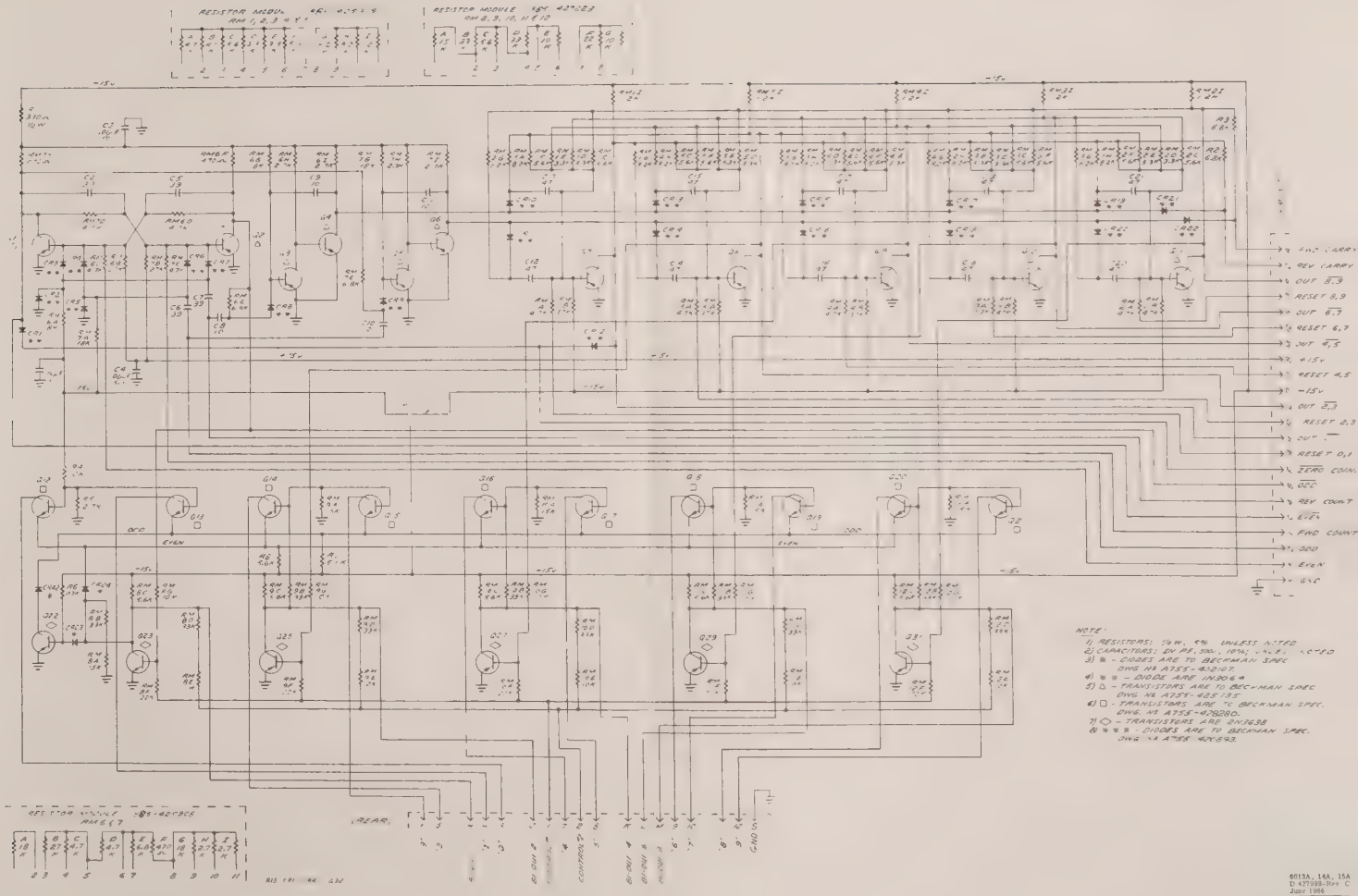


REGULATOR BOARD COMPONENT LAYOUT

6000A Series
C 426753-Rev. C
June 1966

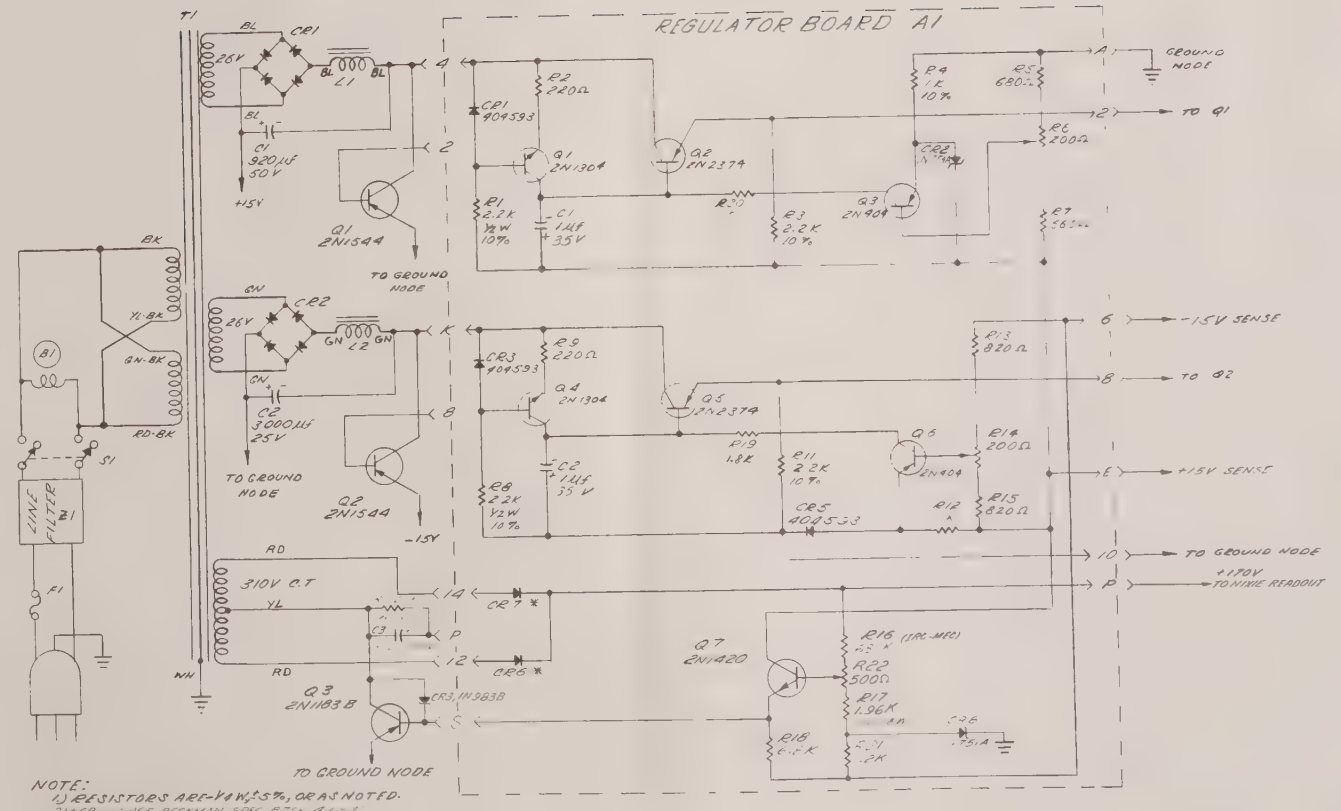
Beckman

BI-QUINARY DCU
(FWD/REV. w/READOUT)
SCHEMATIC DIAGRAM



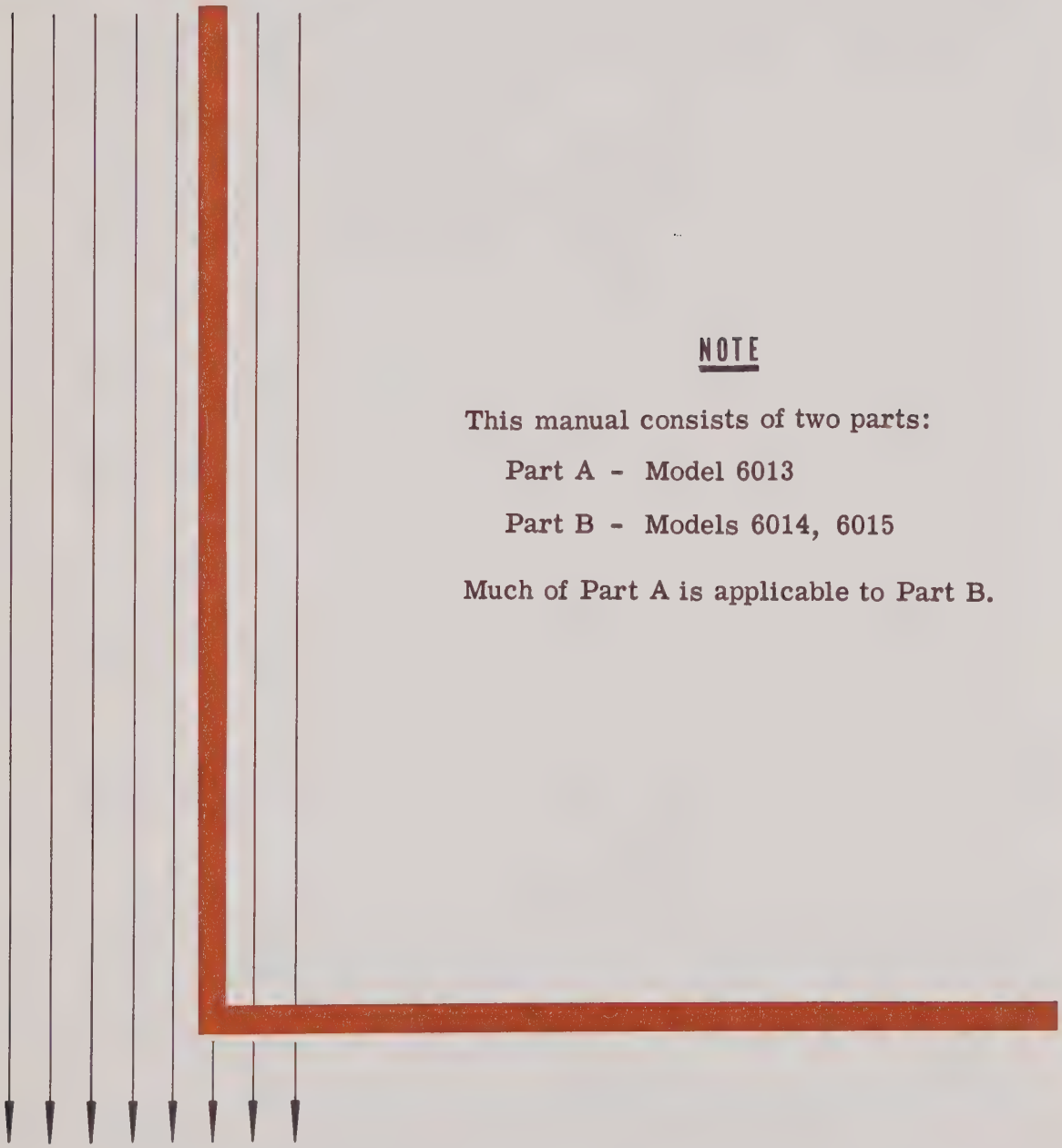
6013A, 14A, 15A
D 427093-Rev C
June 1966

Beckman


REGULATOR BOARD A1
T1
CR1
CR2
CR3
CR4
CR5
CR6
CR7
Q1 2N1544
Q2 2N1544
Q3 2N1183B
Q1 2N1304
Q2 2N2374
Q3 2N404
Q4 2N1304
Q5 2N2374
Q6 2N404
Q7 2N1420
C1 920 µF 50V
C2 3000 µF 25V
C1 1 µF + 35V
C2 1 µF 35V
C3
R1 2.2K ½W 10%
R2 220Ω
R3 2.2K 10%
R4 1K 10%
R5 680Ω
R6 200Ω
R7 56.2Ω
R8 2.2K ½W 10%
R9 220Ω
R10 820Ω
R11 2.2K 10%
R12
R13 820Ω
R14 200Ω
R15 820Ω
R16 (TEMP-MFG)
R17 1.96K
R18
R19 1.8K
R22 500Ω
26V
310V C.T
+15V
-15V
GROUND NODE
TO GROUND NODE
TO Q1
TO Q2
-15V SENSE
+15V SENSE
+170V TO NIXIE READOUT
LINE FILTER
Z1
F1
S1
B1
BK
YL-BK
GN-BK
RD-BK
BL
GN
RD
YL
NOTE:
1) RESISTORS ARE-¼ W, ±5%, OR AS NOTED.
2) *CR... ARE BECKMAN SPEC ... P/N.
5) TRANSISTORS; 1, 2, & 3 ARE MOUNTED ON HEAT SINK

INSTRUCTION MANUAL

MODELS 6013, 6014, 6015
ACCUMULATORS



NOTE

This manual consists of two parts:

Part A - Model 6013

Part B - Models 6014, 6015

Much of Part A is applicable to Part B.

Beckman® INSTRUMENTS, INC.

BERKELEY DIVISION
2200 Wright Avenue
Richmond, California

August 1965

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BERKELEY DIVISION
BECKMAN INSTRUMENTS, INC.

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	Forward-Reverse P.C. Board	D425255
	Input Amplifier P.C. Board	C425611
	DCU P.C. Board	C426102
	Regulator P.C. Board	C423795
	Preset P.C. Board	C426025
	Outline Drawing	65-C-6000-001

continued. . .

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SECTION 1

INTRODUCTION

1.1 GENERAL

The Beckman Model 6013 is a high-speed, solid-state reversing accumulator. It is a five-digit in-line readout instrument with a maximum counting rate of 2 mc and an absolute storage capacity of 99,999.

The Model 6013 can accept either one or two lines of input data, and can add or subtract a single line of data from a prior accumulated sum. It can accept two lines of input data and either add both lines or add one line and subtract the other line from a prior accumulated sum. For any of these operating modes, the new sum is algebraically stored and displayed on a five-digit in-line edge lit readout.

The instrument can provide five digits of four-line binary coded decimal output to accessory recorders.

Input connectors and minor controls are located on the rear of the instrument or are internal adjustments.

1.2 SPECIFICATIONS

Specifications for the Model 6013 are listed in Table 1-1.

Table 1-1. Specifications

Functions	Adds and subtracts counts to any accumulated sum.
Counting Rate	Counts input signal dc to 2 mc in X sense ($\underline{X}$) mode. Counts random input pulses as closely spaced as 0.5 μs in $\underline{X}$, X+Y, and X-Y modes.

continued. . .

Table 1-1. Specifications - continued

Display	
Data Word	5 Digits, 00000 to 99999 in-line, edge-lit readout. Display is continually updated during counting.
Sign Indication	Positive and negative symbols (+ and -) indicating sign of accumulated sum is displayed at left of numerical readout.
GATE OPEN Indication	Indicates condition of count gate (open or closed).
Trigger Adjustment	±10 V internal adjustment.
Environmental	
Temperature	Operating: 0°C to 55°C Storage: -18°C to 75°C
Humidity	Operating: 85% RH; 40°C, 24 hours.
Altitude	Operating: 10,000 ft; storage 50,000 ft.
Power Requirements	115 V ac; 50-60 cycles, 56 watts.
Dimensions	3-1/2" H x 19" W x 17" D
Weight	28 lbs.

1.3 OPTIONS

Table 1-2 lists the options available with Model 6013.

Table 1-2. Options with Models 6013, 6014, 6015

Option	Description
DE	Relay racks. On request.

continued. . .

Table 1-2. Options with Models 6013, 6014, 6015 - continued

Option	Description
DH	230V ac line voltage. Power transformer wired for 230 v ±10%, 50 to 60 cps.
DJ	Binary coded decimal output. Five digits of four-line 1-2-4-8 BCD output at rear panel 50-pin connector, Amphenol type 57-40500. Includes "+" sign (1) and "-" sign (0). Binary "0" is -10 v to ground, 0.2 ma maximum; binary "1" is -0.8 v, 5 ma maximum. With option DM, 6th digit and OVERFLOW ("0" no overflow or "1" overflow) is included.
DM	Addition of 6th digit and OVERFLOW to display.
DN	Remote display. Data output for remote display available at rear-panel connector. Includes cover plate for vacated front panel display. (Mating connector, cable, and cable length requirements available on request.)
DO	Model 6014 only: Addition of relay output at preset coincidence. Model 6015 only: Addition of relay output at each preset coincidence.
DP	Anticoincidence to accommodate absolute coincidence of X and Y inputs; 1 mc maximum at each input.
DQ	Tilt foot handles to replace rack-handle adaptors.

SECTION 2

OPERATION

2.1 GENERAL

The Model 6013 can accept two lines of input data, X and Y. These inputs are algebraically added to any prior accumulated sum according to the desired mode of operation.

Figure 2-1 shows the front-panel controls and readout display. X and Y input connectors on the standard instrument are located on the rear panel, as shown in Figure 2-2. (Rear panels for the Models 6013, 6014, and 6015 are identical.)

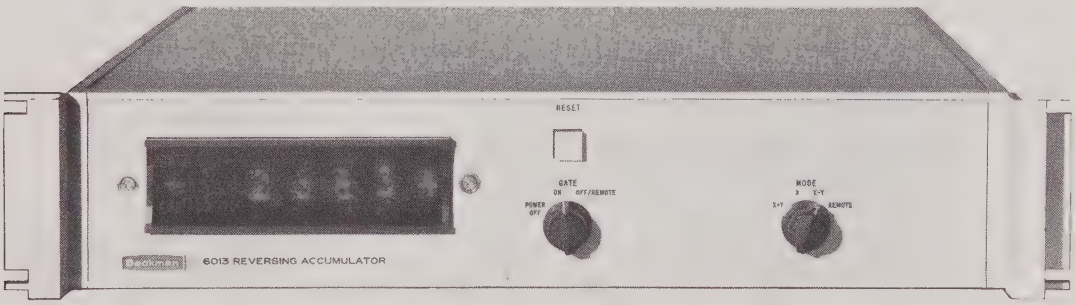


Fig. 2-1. Model 6013 Front Panel

2.2 APPLYING POWER

The instrument is ready to use as it arrives from the factory. To energize the instrument, plug the power cord into a 117 vac, 50 to 60 cycle source. Turn the GATE switch to ON or OFF/REMOTE, thus energizing all circuits in the instrument.

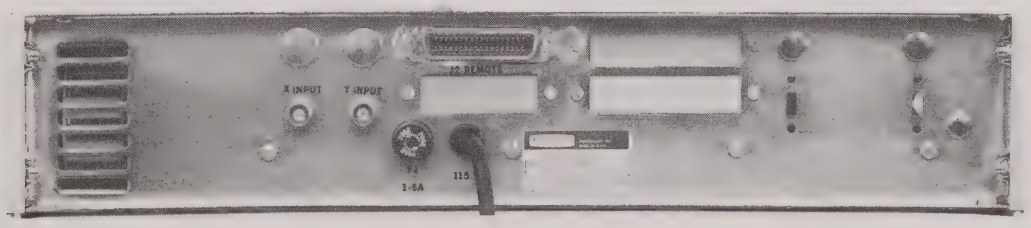


Fig. 2-2. Rear Panel Connectors

2.3 MODES OF ACCUMULATION

The modes of accumulation are selected with the MODE selector on the front panel. The mode of accumulation associated with each position is listed in Table 2-1.

Table 2-1. Modes of Accumulation

Mode	Operation
X + Y	Inputs X and Y are both added positively to the accumulated sum at a maximum rate of 2,000,000 bits per second. At least 0.5 μs separation is required between inputs.
X - Y	Input X is algebraically added while input Y is algebraically subtracted to the accumulated sum at a maximum rate of 2,000,000 bits per second. At least 0.5 μs separation is required between successive inputs.
X (Sense)	Input Y is disabled. Data on input X can be algebraically added to or subtracted from the accumulated sum at a maximum rate of 2,000,000 bits per second. Direction of count (positive or negative sense) is controlled on the remote connector. At least 1 μs must intervene between any sense change and the preceding bit of input data.
Remote	Mode of accumulation is selected by grounding the proper pin(s) on the remote connector. a) X+Y Mode: Ground Pin 16. b) X Mode: Ground Pin 17. c) X-Y Mode: Ground Pin 18.

2.3.1 Anticoincidence Option

As described in Table 2-1, minimum separation between successive inputs on X and Y is 0.5 μs.

With the anticoincidence option, simultaneous input events on X and Y can be counted. The anticoincidence circuits provide approximately 450 nanosecond separation between simultaneous inputs, thus eliminating the restriction of 0.5 μs separation.

2.4 EXTERNAL CONTROLS AND CONNECTORS

Most operating controls are located on the front panel as shown in Figure 2-1. X and Y INPUT connectors, BCD data output connector and remote connector are located on the rear panel as shown in Figure 2-2.

Table 2-2 explains each control on the front panel. Table 2-3 explains the function of each rear panel connector.

Table 2-2. Front Panel Controls (Model 6013)

GATE Switch	In ON or OFF/REMOTE, all circuits in the instrument are energized. ON: Count gate is open and the instrument accumulates X and Y inputs according to the selected mode. OFF/REMOTE: Gate control is transferred to the remote connector. With pin 33 grounded, count gate is open. With pin 33 open circuit, count gate is closed. With the GATE switch in OFF/REMOTE, pin 32 on the remote connector is ground.
MODE Selector	Each position on the MODE selector is explained in Table 2-1.
RESET	At any instant of time, the accumulator can be reset to zero by depressing the RESET button.

Table 2-3. Rear Panel Connectors

X and Y INPUT Connectors J1, J3 (Type BNC)	X and Y input data is applied at these connectors.
REMOTE Connector, J2 (36-Pin Amphenol 57-40360)	Provides remote selection of slope, mode, remote gate control, and remote reset. (Refer to Table 2-4.)

2.4.1 REMOTE Connector (J2)

A 36-pin connector, J2, permits remote gating, mode and slope selection, and reset. In all cases desired gating, reset, and selection requires only a contact closure to ground of the proper pin(s). Table 2-4 shows pin numbering on the remote connector.

Table 2-4. Model 6013 Remote Connector Pin Numbers

Pin Number	Function	Pin Number	Function
1	X - Slope Select	19	Y - Slope Select
2	Ground	20	Ground
3	*	21	*
4	*	22	*
5	*	23	*
6	*	24	*
7	*	25	*
8	*	26	*
9	*	27	*
10	*	28	*
11	*	29	*
12	*	30	*
13	*	31	*
14	*	32	Ground when GATE is OFF/REMOTE
15	Ground when MODE is REMOTE	33	GATE ON
16	X+Y MODE	34	Sense Control
17	X MODE	35	Ground
18	X - Y MODE	36	Remote Reset

*Not used in standard Model 6013

2.5 INTERNAL CONTROLS

2.5.1 Triggering Level Adjustment

The triggering level adjustment and test points are located on the amplifier boards and are accessible from the top of the instrument. There are two test points marked on the board: LEVEL and TEST. Voltage appearing at the LEVEL terminal is the actual triggering level, i.e., value which the input voltage must exceed in order to trigger the input circuit. Voltage appearing at TEST is the actual output from the amplifier.

The adjustment procedure is as follows:

1) Connect a voltmeter of at least 1% accuracy to the LEVEL test point and an oscilloscope to the TEST output.

2) Connect a signal generator to the amplifier input and set the rms voltage to the desired level using a 100kc signal.

3) Using the potentiometer mounted on the amplifier board, adjust the discriminator for maximum sensitivity. This is indicated by the appearance of an ouput pulse train with approximately 50% duty cycle.

4) Continue triggering level adjustment until the output pulse is seen to trigger at the desired instant of time. This is done by shifting the time of occurrence of the leading edge of the output pulse.

5) The actual triggering level (plus hysteresis) is indicated by the DC voltmeter. A reading of approximately 0 volts indicates maximum sensitivity.

2.5.2 Slope Selection

The slope control is a contact closure to ground on the remote connector (pin 1 or 19 for X or Y). It determines which slope (positive or negative) of the input signal will trigger an output pulse. Figure 3-3 in Section 3 shows the voltage discriminator output with a sine wave input and the effect of + and - slope switch positions.

Select desired slope as follows:

1) For positive (+) slope triggering, pin 1 or 19 (X or Y input, respectively) on the remote connector (J3) must be an open circuit.

2) For negative (-) slope triggering the pin must be grounded.

2.5.3 Sense Selection in X MODE

Before operating the instrument in the X (sense) mode, the operator must select the correct sense. A forward (+) sense is defined as going from negative infinity toward positive infinity (+100,000). A reverse (-) sense is defined as going from positive infinity toward negative infinity (-100,000).

Sense control is a contact closure to ground on the remote connector.

To select sense, follow this procedure:

1) For forward sense selection, pin 34 on the remote connector must be an open circuit.

2) For reverse sense selection, pin 34 on the remote connector must be grounded.

SECTION 3

THEORY OF OPERATION

3.1 INTRODUCTION

This section describes the basic operating theory of the Model 6013. Information in this section is primarily from a functional approach and minimizes any detailed description of circuit operation.

Logic symbols are defined in the Appendix and are listed along with typical circuits.

3.2 GENERAL OPERATION

The functional boards in the Model 6013 are shown in Figure 3-1. Information from the data source to accessory recorders and readout display is transmitted through the instrument according to the following sequence.

1) Data is applied at the inputs to the X and Y amplifiers. The amplifier generates a positive true output which is triggered by the positive or negative slope of the applied signal. Duration of the output is determined by the time the applied signal exceeds the discriminator level. The output is applied to the forward-reverse logic board.

2) The forward-reverse logic accepts the X or Y input and generates a signal on either the "forward" output or "reverse" output as determined by the operating mode (and sense, if X MODE), sign of the accumulated sum, and whether or not the accumulated sum is zero. The resulting "forward" or "reverse" signal is applied to the accumulator control board.

3) The accumulator control board provides the necessary gating action in the instrument. A signal on the forward or reverse line is either transmitted to the decimal counters or terminated in the control board depending on the state of the count gate (open or closed). The reset generator is also on the accumulator control board.

4) The decimal counting units (DCU's) perform the basic addition and subtraction operations and store the accumulated sum. The DCU's have forward and reverse input lines. A signal on the forward line

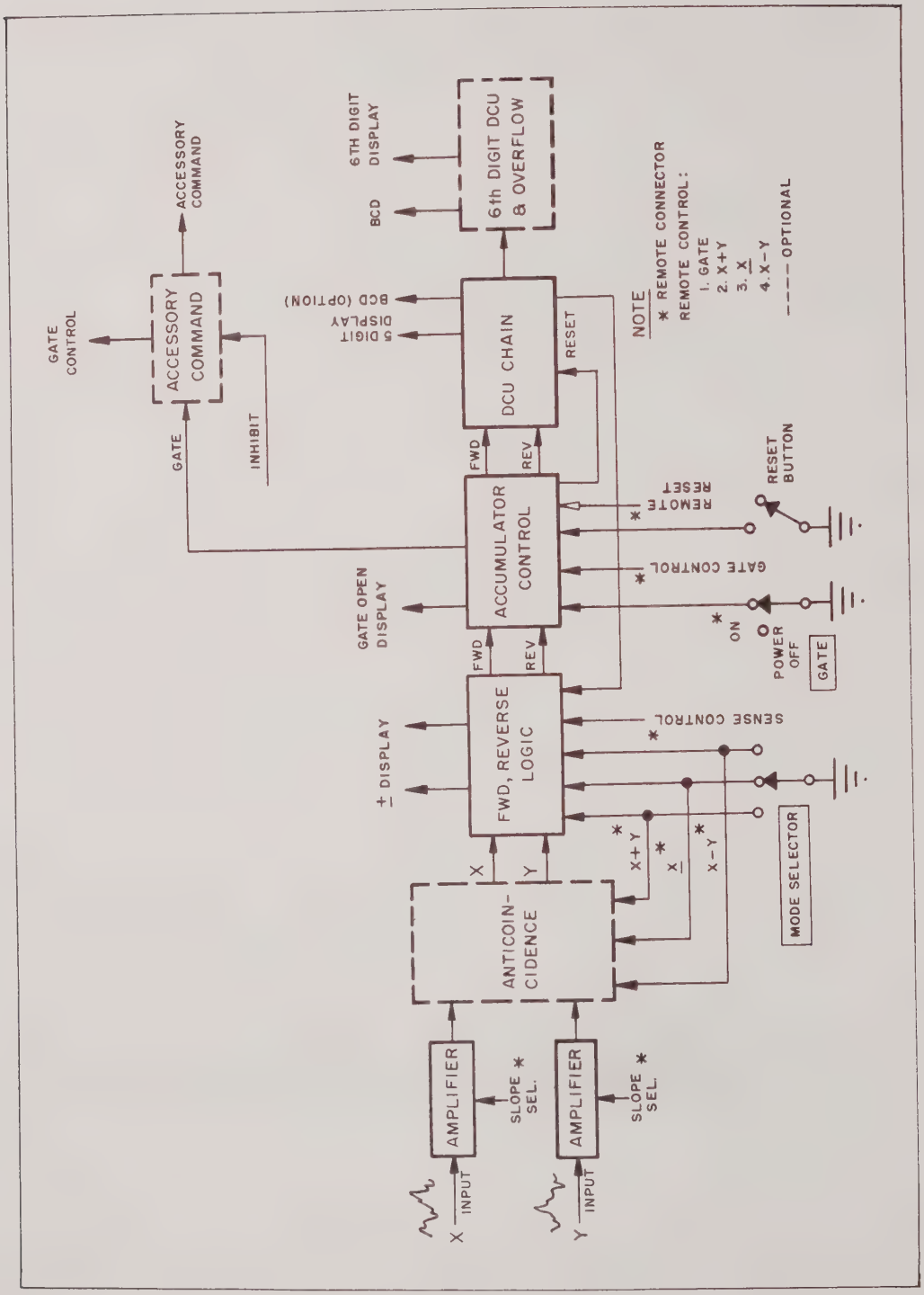


Fig. 3-1. Model 6013 Functional Blocks

increases the absolute value of the accumulated sum, whereas a signal on the reverse line decreases the absolute value of the accumulated sum. The DCU's provide outputs to indicator lamps in the display.

3.3 INPUT AMPLIFIERS

Each input amplifier consists of a discriminator amplifier input circuit followed by slope selection logic.

The discriminator circuit is a differential amplifier using regenerative positive feedback. The use of such feedback and dc switching levels insures the fast switching time which is essential in high frequency applications.

The slope selection logic permits triggering on either the positive or negative slopes of the input signal. An input to the discriminator circuit generates a 0.8 volt p-p positive true signal to the slope selection circuits and appears at the amplifier output as a positive true pulse (-7 volts to ground). If a positive slope is selected, the output is triggered by the leading edge of the discriminator output, whereas if a negative slope is selected, the output is triggered by the trailing edge. Figure 3-2 shows the slope selection logic. Figure 3-3 shows the result of amplifier discrimination and slope selection.

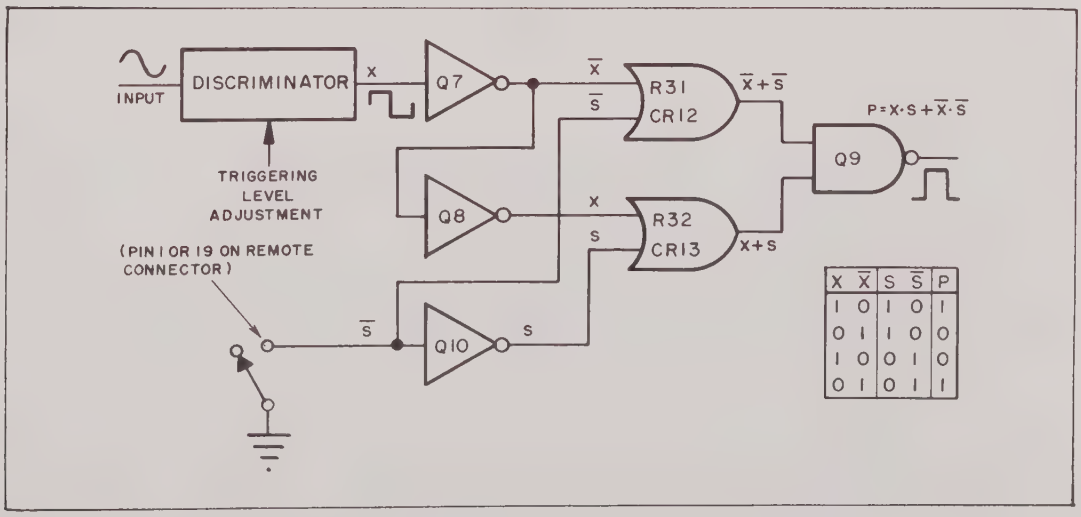


Fig. 3-2. Slope Selection Logic Diagram

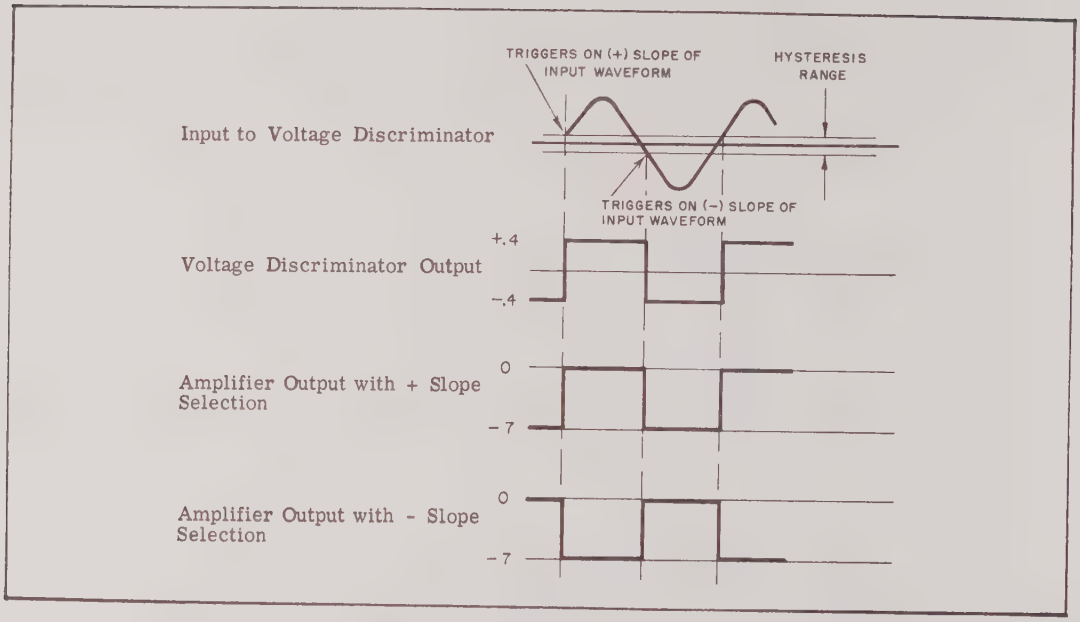


Fig. 3-3. Amplifier Input and Output Signals

3.4 FORWARD AND REVERSE LOGIC BOARD

3.4.1 General

The Forward-Reverse logic couples inputs from the two amplifiers to the control unit and decimal counting units. This is accomplished according to the mode of operation desired and the sign of the accumulated sum.

The forward-reverse logic provides two input lines to the control unit, one for FORWARD and the other for REVERSE operation of the DCU chain. Transmission of signals appearing on these lines to the DCU chain is controlled by the gating action of the control unit. The transmission of a signal on the FORWARD line causes an increase in the absolute value of the accumulated sum, whereas the transmission of a signal appearing on the REVERSE line causes a decrease in the absolute value of the accumulated sum.

3.4.2 Sign Indication

Logic for the sign indication is shown in Figure 3-4. The outputs from a flip-flop (Q8 and Q9) are used to indicate + or - sign. Application of "set" and "clear" pulses result in POSITIVE and NEGATIVE sign indications, respectively.

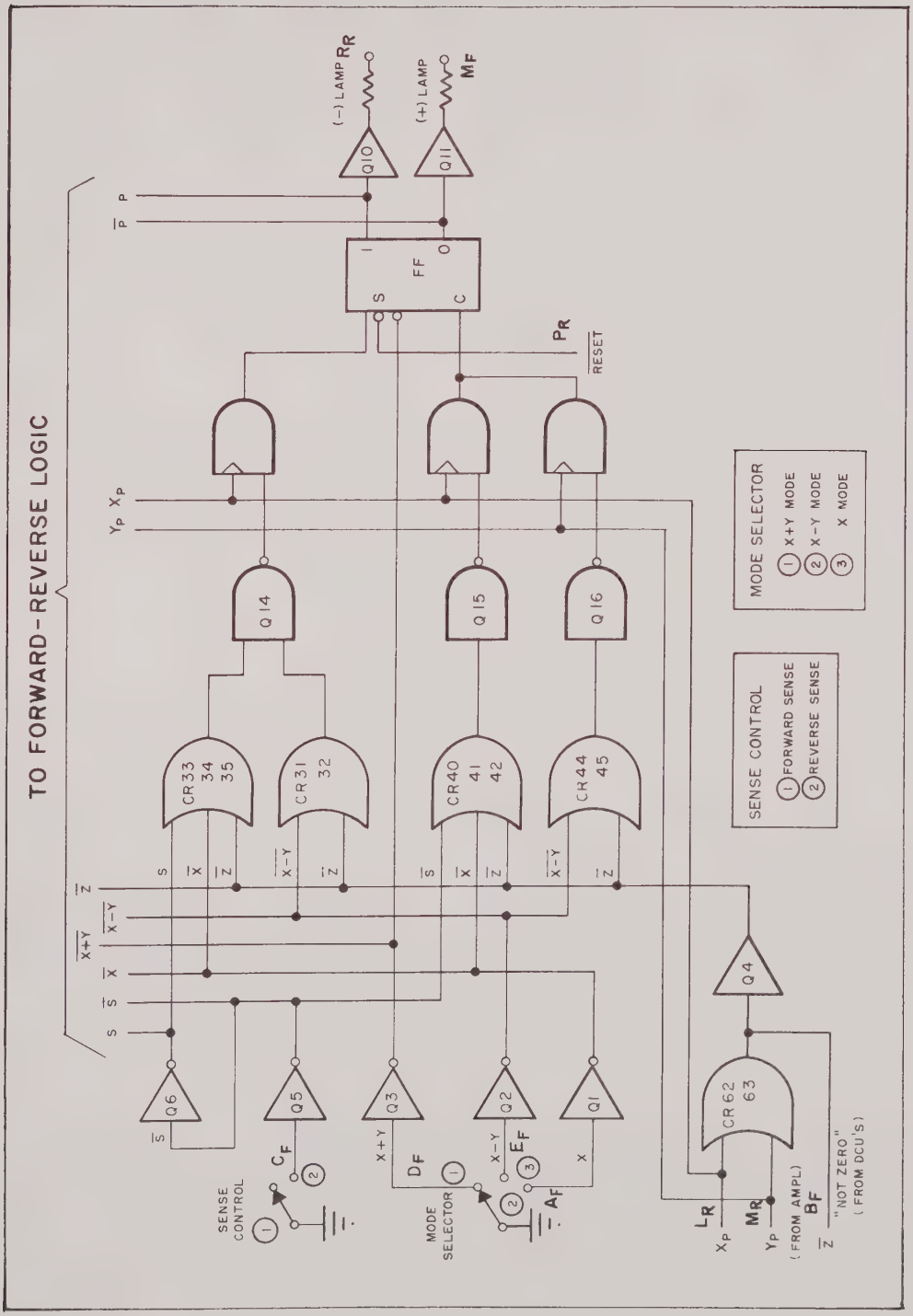


Fig. 3-4. Sign Indication Logic of Forward-Reverse Logic Board

As shown in Figure 3-4, a "set" pulse is produced only when a pulse from amplifier X (X_p) occurs, and only when the AND gate is open. To operate the AND gate, either of the following conditions must be satisfied:

1) All inputs to the OR gate (CR33, 34, 35) are logic "0", that is:
   a) $\overline{\text{Zero}}$ ($\overline{Z}$) = logic "0"; the accumulator displays ±00000.
   b) Mode of operation is X.
   c) Sense is forward.

2) All inputs to the OR gate (CR31, 32) are logic "0", that is:
   a) $\overline{Z}$ = logic "0"; the accumulator displays ±00000.
   b) Mode of operation is X - Y.

In either case, the accumulator must register ±00000 before the flip-flop can be set and display the POSITIVE sign. A "clear" pulse resulting in NEGATIVE sign display is produced with <u>either</u> X_p or Y_p.

1) X_p clears the flip-flop when all inputs to the OR gate (CR40, 41, 42) are logic "0".
   a) $\overline{Z}$ = logic "0"; the accumulator displays ±00000.
   b) Mode of operation is X.
   c) Sense is reverse.

2) Y_p clears the flip-flop when all inputs to the OR gate (CR44, 45) are logic "0".
   a) $\overline{Z}$ = logic "0"; the accumulator displays ±00000.
   b) Mode of operation X - Y.

In any case, the sign displayed by the accumulator cannot change if the accumulator contains any numerical information other than zero. Sign changes can occur only when the accumulator registers ±00000. Appropriate sign changes according to the preceding discussion are summarized in Table 3-1.

The sign resulting from a RESET signal is POSITIVE in any operating mode.

The empty accumulator assumes the sign of the preceding absolute number. Example: Operating in the X (REVERSE) mode, assume the accumulator contains +00001. An X_p signal will bring the accumulator to "plus" 00000. Had the accumulator contained -00001, the X_p signal would have brought the accumulator to "minus" 00000.

Table 3-1. Forward-Reverse Logic Showing Sign Changes

Mode	Display Before Input	Input	Display After Input
X (Fwd.)	+00000	X_p	+00001
X (Fwd.)	-00000	X_p	+00001
X (Rev.)	+00000	X_p	-00001
X (Rev.)	-00000	X_p	-00001
X - Y	+00000	X_p	+00001
X - Y	+00000	Y_p	-00001
X - Y	-00000	X_p	+00001
X - Y	-00000	Y_p	-00001
X + Y	+00000	X_p	+00001
X + Y	+00000	Y_p	+00001

3.4.3 Forward-Reverse Operation

The remainder of the "forward-reverse" logic board provides the "accumulate forward" (FWD.) and "accumulate in reverse" (REV.) commands to the decimal counting units through the intermediate accumulator control unit. The logic diagram for this operation is shown in Figure 3-5.

Outputs from this part of the circuit board depend on the mode of operation (and sense, when operating in the X mode), the sign of the accumulated sum, and the state of the DCU chain (either ZERO or $\overline{\text{ZERO}}$).

The commands "accumulate forward" or "accumulate in reverse" (FWD or REV) are triggered by pulses from either amplifier X or Y. The respective FWD and REV control signals for each amplifier are designated X_F, X_R, Y_F, and Y_R (Figure 3-5). Thus, X_p can trigger a FWD command only if X_F is "TRUE" to maintain the proper AND gate in the open state. For Y_P to trigger the FWD command, Y_F must be TRUE in order to maintain the proper AND gate in the open state. Likewise, X_R and Y_R must be TRUE to maintain their respective AND gates open thus enabling the amplifier signals to produce a REV command.

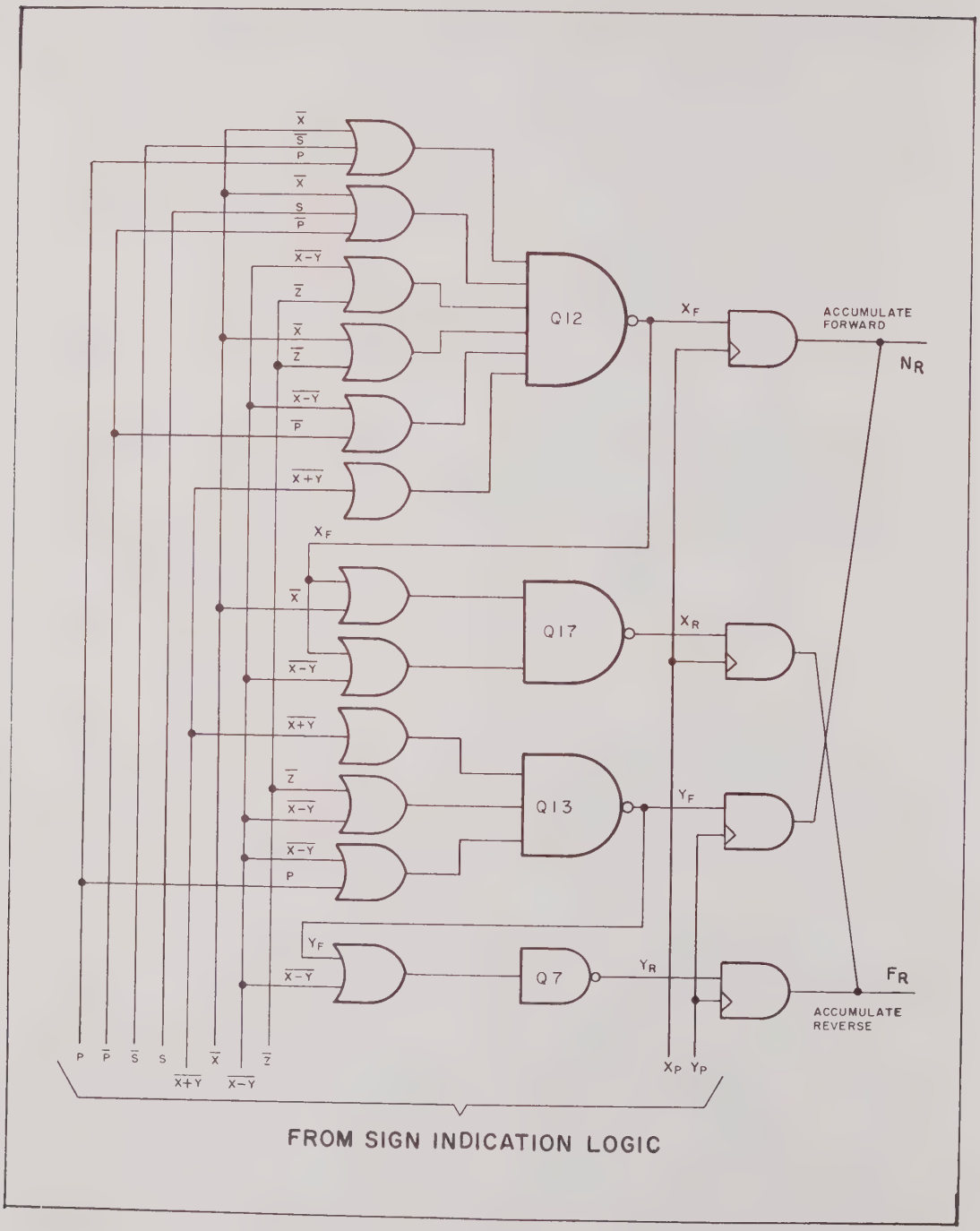


Fig. 3-5. Forward-Reverse Logic of F-R Logic Board

Conditions for the four FWD-REV control signals to be TRUE are as follows:

1) X_F TRUE: Q12 must be turned ON, that is, at least one of the six inputs to Q12 must be FALSE. This requires all inputs to at least one of the six OR gates to be FALSE. Written symbolically:

$$X_F = \underset{(a)}{(\underline{X-Y}\cdot P)} + \underset{(b)}{(\underline{X+Y})} + \underset{(c)}{(\underline{X}\cdot S\cdot \overline{P})} + \underset{(d)}{(\underline{X}\cdot \overline{S}\cdot P)} + \underset{(e)}{(\underline{X-Y}\cdot Z)} + \underset{(f)}{\underline{X}\cdot Z}$$

Therefore, any of the following six conditions will result in X_F TRUE:

a) X - Y mode when sign is (+).

b) X + Y mode.

NOTE

Operation in the X + Y mode should never result in a (-) sign. This precludes changeover to the X + Y mode at a time when the sign is already (-). Doing this will result in incorrect accumulation, since negative numbers will automatically be converted to positive numbers. For most purposes, this is an undesirable operation and could result in incorrect information unless the operator is aware of what has occurred.

c) X mode in (-) sense when the sign is (-).

d) X mode in (+) sense when the sign is (+).

e) X - Y mode when the accumulator is "empty".

f) X mode when the accumulator is "empty".

2) X_R TRUE: Q17 must be turned ON, that is, at least one of the inputs to Q17 must be FALSE. This requires all inputs to either of the two OR gates to be FALSE (this requires X_F to be FALSE). Written symbolically:

$$X_R = (X\cdot \overline{X}_F) + (X-Y\cdot \overline{X}_F) \quad \text{where}$$

$$\overline{X}_F = \overline{(\underline{X+Y})}\cdot(\underline{\overline{X}}+\underline{\overline{S}}+P)\cdot(\underline{\overline{X}}+S+\overline{P})\cdot(\overline{\underline{X-Y}}+\overline{Z})\ (\underline{\overline{X}}+\overline{Z})\cdot(\overline{\underline{X-Y}}+\overline{P})$$

Therefore, X_R TRUE results only when operating in either X - Y or X modes and under specific conditions related to operation in each mode. The following three conditions will result in X_R TRUE:

a) X mode in (+) sense, when sign is (-), accumulator is not empty.

b) X mode in (-) sense when sign is (+), accumulator is not empty.

c) X - Y mode, when sign is (-), accumulator is not empty.

3) Y_F TRUE: Q13 must be turned ON, that is, at least one of the three inputs to Q13 must be FALSE, requiring all inputs to at least one of the three OR gates to be FALSE. Symbolically:

$$Y_F = \overset{(a)}{(\underline{X+Y})} + \overset{(b)}{(\underline{X-Y} \cdot Z)} + \overset{(c)}{(\underline{X-Y} \cdot \overline{P})}$$

Therefore, any of the following three conditions will result in Y_F TRUE:

a) X + Y mode.

b) X - Y mode and accumulator is empty.

c) X - Y mode and sign is (-).

4) Y_R TRUE: Q7 must be turned ON, requiring both inputs to the OR gate to be FALSE. Symbolically:

$$Y_R = (\underline{X-Y}) \cdot \overline{Y}_F = (\underline{X-Y}) \cdot (\overline{\underline{X+Y}}) \cdot (\overline{\underline{X-Y}} + \overline{Z}) \cdot (\overline{\underline{X-Y}} + P)$$

Therefore, Y_R TRUE can only occur when operation is in the X - Y mode, accumulator is not empty and sign is (+).

Table 3-2 summarizes steps (1) through (4). The table shows the resulting direction command when pulses are received from amplifiers X or Y under all possible input conditions.

3.4.4 Example of Accumulator Operation

Assuming the FWD-REV command signals to be ungated by the accumulator control unit, the accumulation process proceeds according to the operation outlined in Tables 3-1 and 3-2. Figure 3-6 illustrates the accumulation process for the X - Y mode.

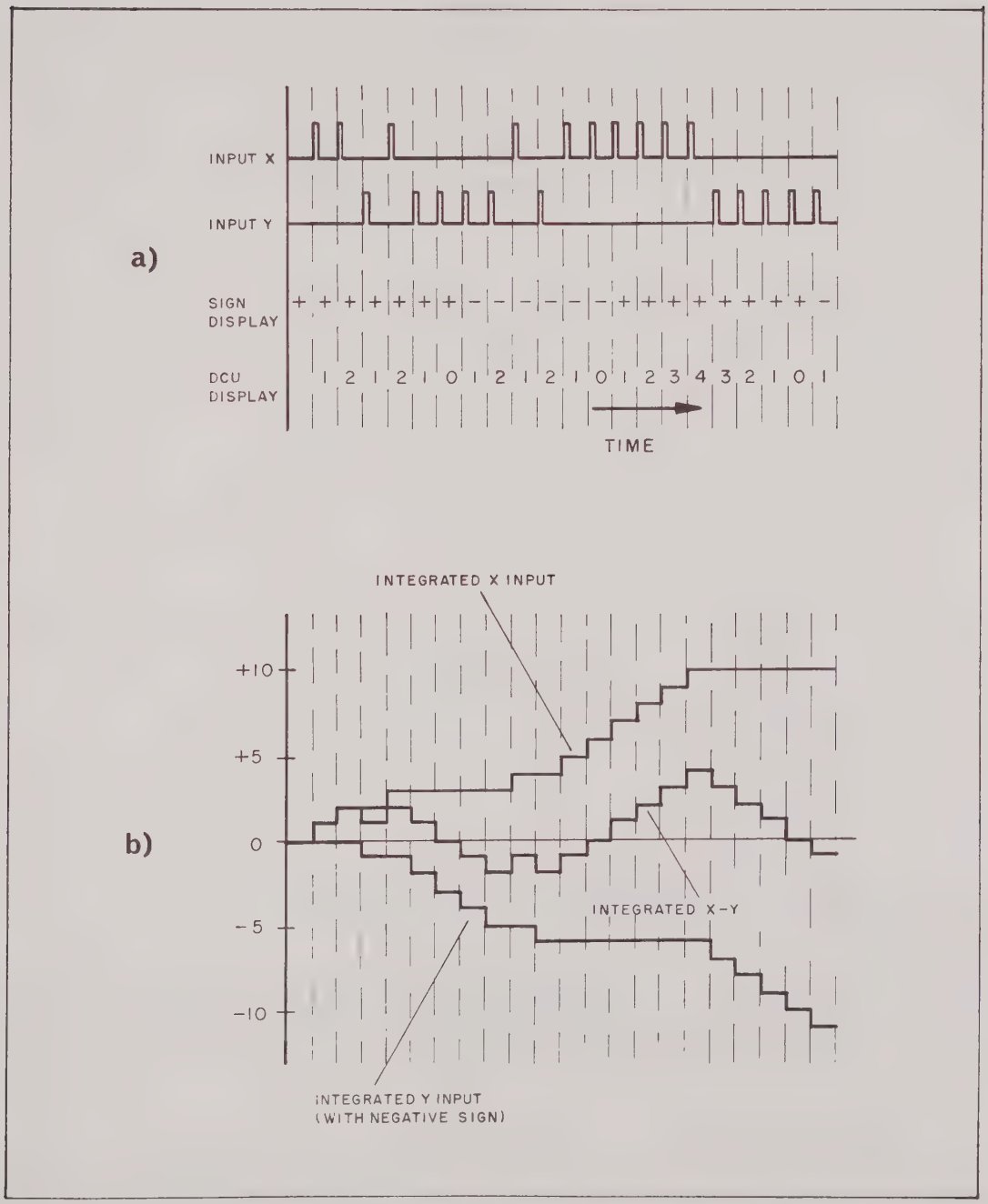


Fig. 3-6. Example of Accumulator Operation in X - Y Mode
a) Sign and Numerical Display.
b) Numerical Integration of X - Y.

Table 3-2. Forward-Reverse Operation

Mode	Sense	$\overline{\text{Zero}}$	Sign	Input (X)	Input (Y)
X+Y	±	1 or 0	+**	FWD	FWD
X-Y	±	0	+	FWD	FWD
	±	0	-	FWD	FWD
	±	1	+	FWD	REV
	±	1	-	REV	FWD
X	-	0	-	FWD	*
	+	0	+	FWD	*
	-	0	+	FWD	*
	+	0	-	FWD	*
	+	1	-	REV	*
	-	1	+	REV	*
	+	1	+	FWD	*
	-	1	-	FWD	*

* No output on either FWD or REV lines.

**Theoretically, operation in the X+Y mode never results in a (-) sign. See note under step (1) of paragraph 3.4.3.

3.5 ACCUMULATOR CONTROL BOARD

3.5.1 General

A logic diagram for the accumulator control board is shown in Figure 3-7. The board contains two circuits: a reset generator circuit, and a count gate circuit.

3.5.2 Reset Generator

Reset is a contact closure to ground which triggers a 200 nanosecond positive-true pulse to all DCU's. It also triggers a 200 nanosecond negative-true reset pulse to all flip-flops. The reset pulse for the DCU's appears at the emitter of Q7 (pin R_F), while the reset pulse for the flip-flops appears at the emitter of Q5 (pin N_F).

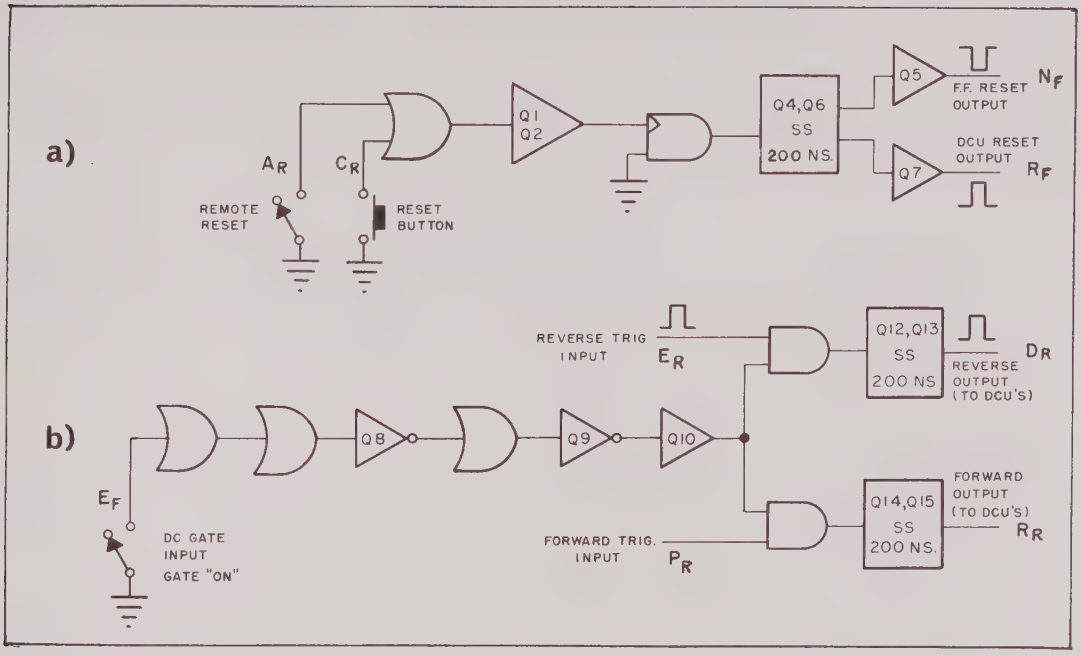


Fig. 3-7. Accumulator Control Board Logic Diagram
a) Reset Generator Logic
b) Count Gate Logic

3.5.3 Count Gate

The front-panel GATE switch in the ON position grounds pin E_F (logic "1") and causes the AND gate to the forward and reverse single-shots to open. A forward or reverse pulse from the forward-reverse logic board is able to then activate an output single-shot, producing a positive true (-6 volts to ground) 200 nanosecond pulse to the decimal counting units. A reverse count appears at the collector of Q12 (pin D_R). A forward count appears at the collector Q14 (pin R_R).

3.6 DECIMAL COUNTING UNITS (DCU's)

The basic counting circuits in the instrument consist of a chain of five decimal counting units connected in tandem. Each DCU provides outputs to the display and can provide BCD outputs to external recorders (option). The five DCU's provide the zero coincidence signal to the

forward-reverse logic board when all of the DCU's register zero. (In the Models 6014 and 6015 Preset Accumulator, each DCU also provides a signal to the preset switches.)

Since each DCU generates one output pulse for every ten input pulses, the bank of five DCU's performs as a decimal counter with an absolute capacity of 99,999.

The DCU's used in the 601X series accumulators have the ability to accumulate in either the forward direction (add) or reverse direction (subtract). If a pulse on the FWD input line is received, the DCU chain increases absolutely by a value of one; if a pulse on the REV input line is received, it decreases absolutely by a value of one.

3.6.1 DCU Technical Characteristics

Table 3-3 lists the technical characteristics of the DCU.

Table 3-3. Technical Characteristics of the DCU

Input Requirements	Positive-going pulse or voltage step, 5-7 volts p-p, less than 20 ns rise time; pulse duration at least 150 ns, from a low impedance source (180 ohms or less at 0 volt input).
Counting Rate	0-2 Mc in forward or reverse direction; requires at least 0.5 μs between successive input pulses.
Output	Binary coded decimal outputs (option). The DCU provides lamp drive (0-9), zero coincidence, available outputs to preset switches; (not used in the Model 6013).

3.6.2 DCU Operation

The DCU divides by 10 in two steps: division by two, then division by five. This type of division requires a binary stage followed by a quinary stage. Therefore, the actual "count" is represented by the states of seven transistors. The bi-quinary decimal code is shown in Table 3-4. The logic voltage levels have been reversed in the bi-quinary as noted in the table. A DCU logic diagram is shown in Figure 3-8. Logic "1" output in the figure corresponds to logic "0" in Table 3-4, and vice versa.

Table 3-4. Bi-Quinary Decimal Code

Binary			Quinary				
Decimal	Q_1	Q_2	Q_7	Q_8	Q_9	Q_{10}	Q_{11}
0	1	0	1	0	0	0	0
1	0	1	1	0	0	0	0
2	1	0	0	1	0	0	0
3	0	1	0	1	0	0	0
4	1	0	0	0	1	0	0
5	0	1	0	0	1	0	0
6	1	0	0	0	0	1	0
7	0	1	0	0	0	1	0
8	1	0	0	0	0	0	1
9	0	1	0	0	0	0	1

Logic "1" (or TRUE) refers to transistor being in OFF state.
Logic "0" (or FALSE) refers to transistor being in ON state.

The binary section alternates between 0 and 1, and changes the state of the quinary once with the acceptance of every two incoming counts. The quinary provides an output to the next DCU in the chain and returns to its original state after every five counts are received from the binary.

The binary changes state when either a FWD or REV count is received, whereas the quinaries change states either progressively in the "forward" direction or "reverse" direction.

Progressive change in the forward direction occurs when there is an increase in magnitude from an odd number to an even number. This is reflected in the circuitry when a higher order transistor turns OFF. For example, assume the DCU displays a decimal "3". Then all quinary transistors would be ON except for Q8. Progressing forward to decimal "4" requires all quinary transistors to be ON except for the next higher order transistor, Q9. For a progressive change in the forward direction to occur, the circuit requires that Q_2 is OFF and that a FWD count is received. If only the latter occurs, and Q_2 is ON, the quinary does not change.

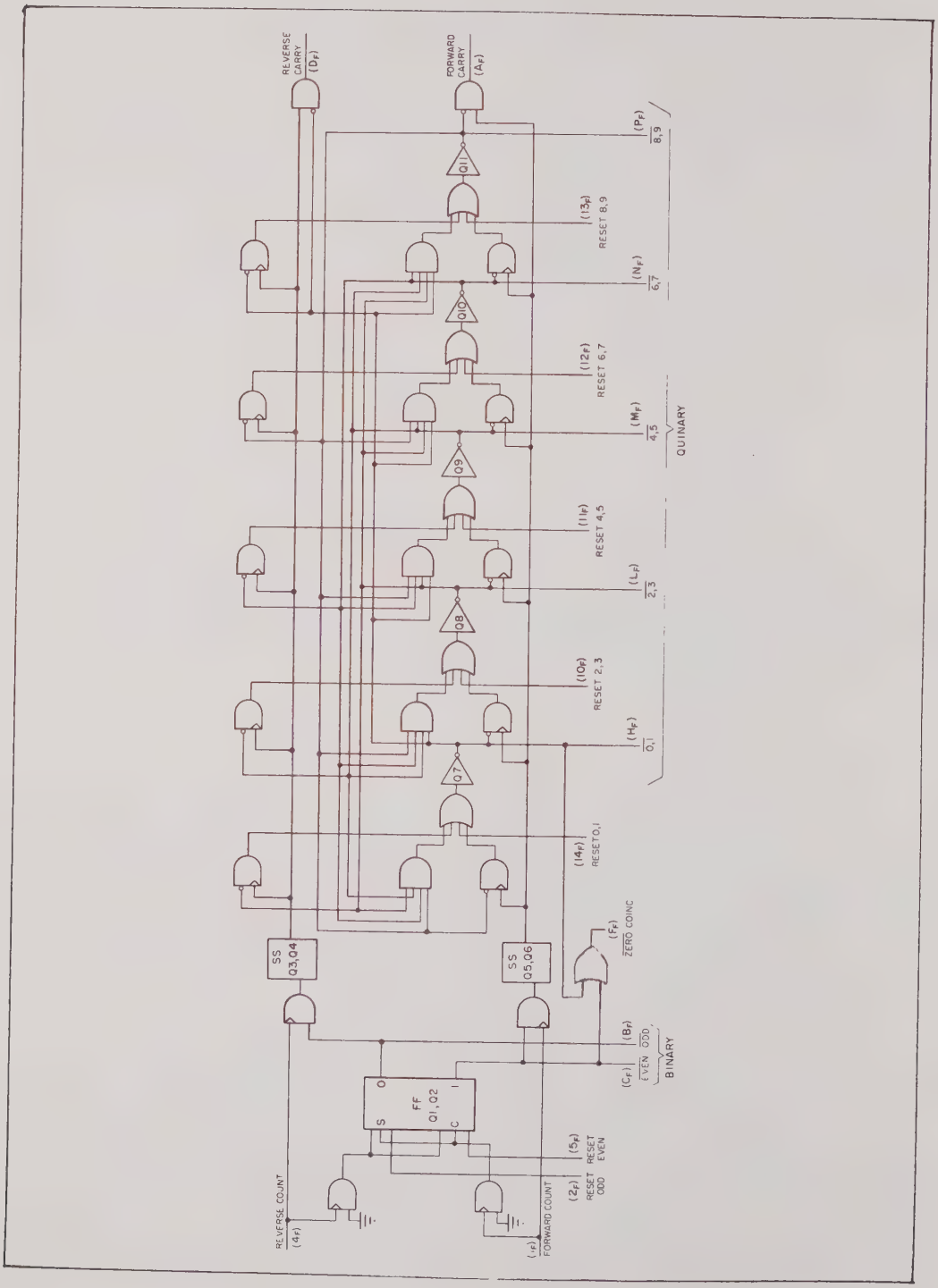


Fig. 3-8. Forward-Reverse Decimal Counting Unit Logic Diagram

Progressive change in the reverse direction occurs when there is a decrease in magnitude from an even number to an odd number. This is reflected in the circuitry when the OFF transistor progresses in the reverse direction.

Going forward from 9 to 0 results in a forward count applied to the next higher order DCU and the bi-quinary resets to decimal zero. Going in reverse from 0 to 9 results in a reverse count applied to the next higher order DCU and resets the bi-quinary to decimal "9". The logic diagram for the basic forward and reverse operation is shown in Figure 3-8.

The five quinary outputs together with the EVEN and ODD lines are combined to provide outputs to lamp drives. The outputs from Q1 and Q7 enter an AND gate to provide the DCU zero coincidence indication.

3.6.3 Lamp Drives

Since the ODD and EVEN outputs are the "common" lines on the lamp blocks, they determine which of the two possible decimal digits are present on the quinary output lines. A typical lamp block - DCU interconnection diagram, is shown in Figure 3-9.

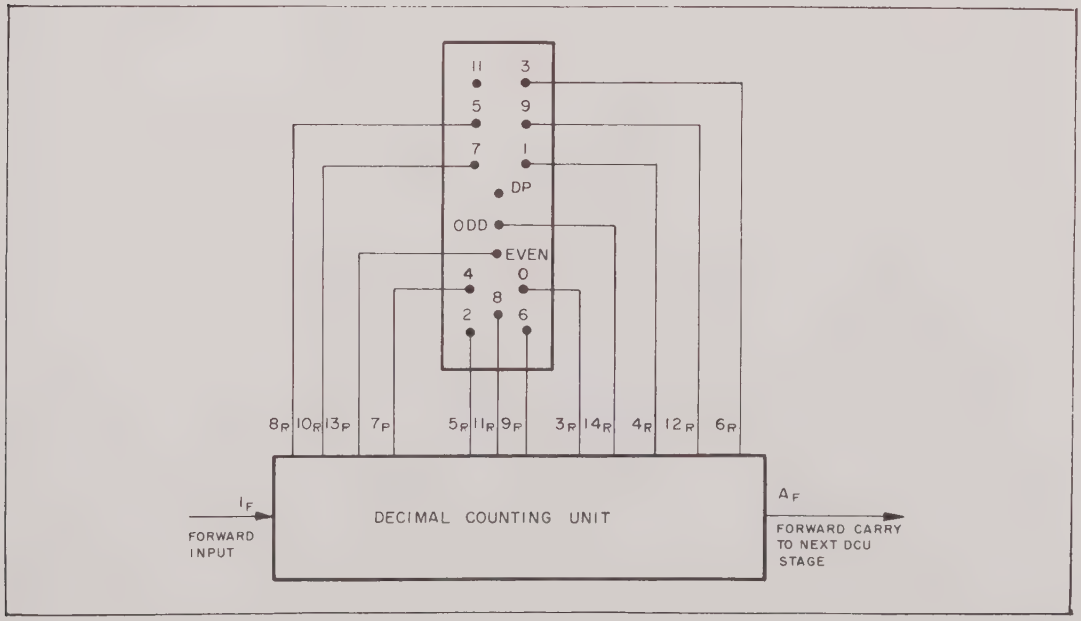


Fig. 3-9. Lamp Block - DCU Interconnection

3.6.4 BCD Outputs (Option)

Outputs from the "count" transistors can be combined to provide BCD outputs to a recorder. Four output lines are used for all codes and changing from one code to another requires a reassignment of weights to each line, and changes in the output circuit.

SECTION 4

SERVICING

4.1 GENERAL

This section provides adjustment procedures and troubleshooting information for the 6000 Series Accumulators.

4.1.1 Required Test Equipment

Table 4-1 lists the test instruments required for servicing the accumulator.

Table 4-1. Recommended Test Equipment

Instrument	Specifications
Oscilloscope	50 mc bandwidth, 3.5 nanosecond rise-time.
Signal Generator	1 cps to 100 kc, 1 volt rms output.
Signal Generator	100 kc to 2 mc, 1 volt rms output.
Volt-Ohmmeter	100,000 ohms/v dc.
Auto Transformer	0 - 130 volts ac, 60 cps.

4.1.2 Printed Circuit Board Identification

Table 4-2 lists the printed circuit boards used in the 6000 Series Accumulators.

Table 4-2. Printed Circuit Boards Used in 6000 Series Accumulators

P. C. Board Detail No.	Description	Model					
		6003	6004	6005	6013	6014	6015
XA 103-203	10^5 FWD/REV DCU	x	x	x	x	x	x
XA 104-204	10^4 FWD/REV DCU	x	x	x	x	x	x
XA 105-205	10^3 FWD/REV DCU	x	x	x	x	x	x
XA 106-206	10^2 FWD/REV DCU	x	x	x	x	x	x
XA 107-207	10^1 FWD/REV DCU	x	x	x	x	x	x
XA 108-208	10^0 FWD/REV DCU	x	x	x	x	x	x
XA 109-209	Accum. Control	x	x	x	x	x	x
XA 110-210	FWD/REV Logic				x	x	x
XA 114	Preset N_1		x	x		x	x
XA 115	Preset N_2			x			x
XA 214	X Amplifier	x	x	x	x	x	x
XA 215	Y Amplifier				x	x	x

4.1.3 Component Location

Use the drawing on the inside top cover of the instrument to locate assemblies and components which are mounted on the main chassis. Components on printed circuit boards may be located using the layout drawings furnished in the manual.

4.1.4 Extension Boards

Two extension boards are supplied with the instrument to provide easy access to components and test points on printed circuit boards during operation.

4.2 ADJUSTMENTS

4.2.1 Power Supply Adjustments

The regulated power supply adjustments are located on Regulator Board A1 (Figure 4-1).

Power supply test points are located on the bottom of the chassis along a horizontal terminal strip (Figure 4-2). Wires from the three terminals are color coded as follows: RED +15V, GREEN -15V, YELLOW -32V.

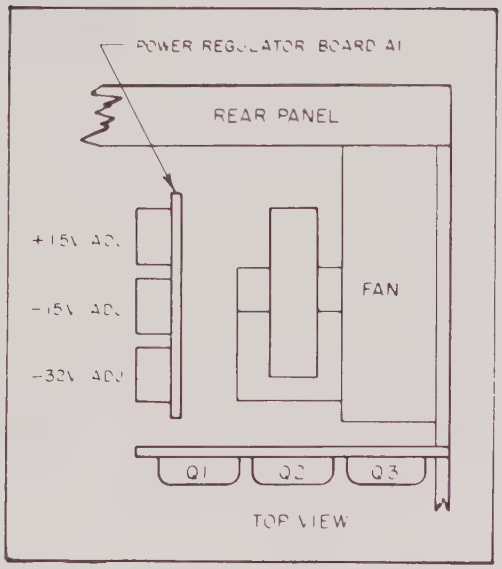


Fig. 4-1. Location of Power Supply Adjustment

4.2.1.1 Adjustment Procedure

CAUTION

Do not remove the Regulator Board (A1) from its receptacle without first unplugging the AC line cord from its power source.

1) Use a voltmeter of at least 1% accuracy. Voltage measurements are referenced to chassis ground.

2) Use Figure 4-2 to locate power supply test points.

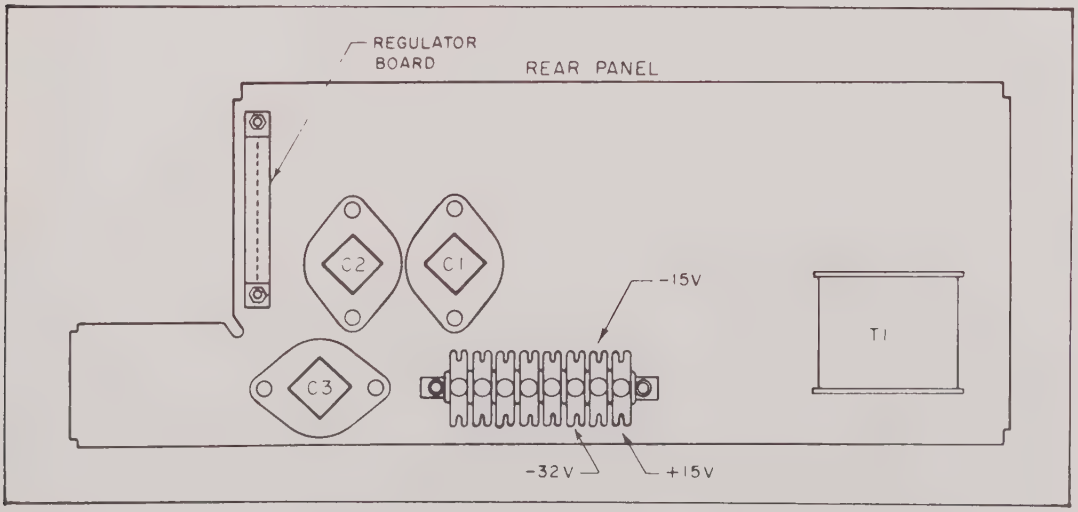


Fig. 4-2. Location of Power Supply Test Points

3) Adjust -15 V ADJ to -15 volts. ±0.2 volt.

4) Adjust -15 V ADJ to -15 volts. ±0.2 volt.

5) Adjust -32 V ADJ to approximately -29.5 volts.

4.2.2 Triggering Level Adjustment

The trigger level adjustment and test points are on the amplifier boards and are accessible from the top of the instrument. There are two test points marked on the board: LEVEL and TEST. Voltage appearing at the LEVEL terminal is the actual triggering level, or value which the input voltage must exceed in order to trigger the input circuit. Voltage appearing at TEST is the actual output from the amplifier. Maximum sensitivity occurs when the level is near zero volts.

4.2.2.1 Adjustment Procedure

1) Connect voltmeter of at least 1% accuracy to LEVEL and OSCILLOSCOPE to TEST.

2) Connect signal generator to amplifier input. Using a 100 kc signal, set the rms voltage to the desired level.

3) Using the potentiometer mounted on the amplifier board, adjust the discriminator for desired sensitivity. Maximum sensitivity is indicated by the appearance of an output pulse train with approximately 50% duty cycle.

4) Actual triggering level (plus hysteresis) is indicated by the dc voltmeter; a reading of approximately 0 volts indicates maximum sensitivity.

4.3 TROUBLESHOOTING

4.3.1 General

Most circuits in the Model 6000 Series Accumulators are mounted on printed circuit boards which can be removed and replaced easily. Troubleshooting can be greatly simplified by replacing boards suspected of being faulty with spare boards which are known to be in good working order. Once the faulty board is found, it can be repaired and returned to operation.

4.3.2 Replacing Components on Printed Circuit Boards

To prevent damage to the printed circuit board and its components, use heat sparingly and work carefully. Follow this procedure for removing a defective component.

1) Melt the solder in the component lead holes and tap the board gently to remove solder around component leads.

2) Straighten component leads with long-nose pliers or soldering aid.

3) Remove the defective component.

4) If component cannot be removed, reheat leads slightly.

To install a new component:

1) Clean lead holes thoroughly.

2) Cut and bend component leads to proper length and shape.

3) Insert leads into holes and solder into place.

NOTE

When installing transistors or diodes, use a heat sink to prevent excessive heat conduction through the component. Long-nose pliers applied between the component and the soldering iron make an effective heat sink.

4.3.3 Over-All Troubleshooting

Troubles can often be isolated to an individual circuit board by observing front panel indications in the various operating modes.

When the faulty board has been located, some of the idealized waveforms and voltage levels given in Section 3 may be helpful in locating the exact problem.

SECTION 1

INTRODUCTION

1.1 GENERAL

The Models 6014 and 6015 are basic Model 6013 type accumulators with the addition of preset capability. Model 6014 provides single preset capability, whereas Model 6015 provides dual preset capability.

The basic forward-reverse accumulation process is performed exactly the same as in the Model 6013. All circuit boards present in the Model 6013 are present in Models 6014 and 6015. The Model 6014 has a single preset board and 5-digit preset select switch added to the Model 6013 circuits and controls. The Model 6015 has two preset boards and two 5-digit preset select switches added to the Model 6013 circuits and comtrols.

The preset accumulators are basic forward-reverse accumulators which perform a specific function when the accumulator reaches a preset number. The three possible functions are basically as follows:

1) Reset accumulator to zero when the accumulator reaches the preset sum, (RESET N).

2) Inhibit further counting when the preset sum is reached; store and display the preset sum indefinitely, (HOLD N).

3) Generate an electrical output when the preset sum is reached; continue uninterrupted counting to 99,999, reset to zero and continue counting, (N LIMIT).

1.2 SPECIFICATIONS

Specifications are the same as for the Model 6013. Counting rate in RESET N function is dc to 1.7 mc.

1.3 OPTIONS

Options for the Models 6014 and 6015 are listed in Table 1-2, Part A, Section 1.

SECTION 2

OPERATION

2.1 GENERAL

Models 6014 and 6015 have the same inputs and front panel controls as the Model 6013. The Model 6014 has an additional output line on which an output signal is generated when the preset limit is reached. Model 6015 has two additional output lines on which output signals are generated when the respective preset limits are reached.

Both instruments have additional controls on the front panel which permit selection of sign of the preset number and the function to be performed when the accumulator reaches the preset number.

The following information regarding operation of the Model 6013 is also applicable to both Models 6014 and 6015.

1) Applying Power (Section 2-2).

2) Modes of Accumulation; Table 2-1, MODE Selector; Anticoincidence option (Section 2-3).

3) Rear Panel Connectors (Table 2-3).

4) Internal Controls (Section 2-5).

2.2 EXTERNAL CONTROLS AND CONNECTORS

Most operating controls are located on the front panel as shown in Figure 2-1 (Model 6014), or Figure 2-2 (Model 6015). X and Y input

Fig. 2-1. Model 6014 Front Panel

connectors, BCD data output connection (option), and remote connector are located on the rear panel exactly as in the Model 6013 (shown in Figure 2-2 of Model 6013 manual).

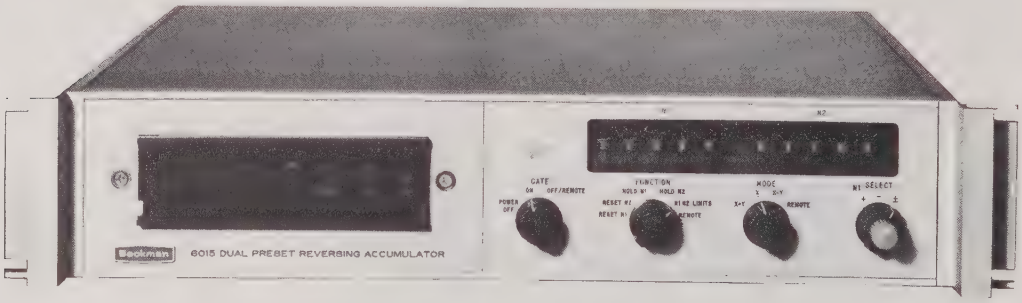


Fig. 2-2. Model 6015 Front Panel

Table 2-1 explains each control on the front panel. Table 2-2 explains the function of each rear panel connector.

Table 2-1. Front Panel Controls (Models 6014, 6015)

Name	Function
GATE Switch	In ON or OFF/REMOTE, all circuits in the instrument are energized. ON: Count gate is open and the instrument accumulates the X and Y inputs according to the selected mode. OFF/REMOTE: Gate control is transferred to the remote connector. With Pin 33 grounded, count gate is open. With Pin 33 open circuit, count gate is closed. With the GATE switch in OFF/REMOTE, Pin 32 on the remote connector is ground.
MODE Selector	Each position on the MODE selector is exactly the same as for the Model 6013. Refer to Table 2-1 of the 6013 manual.

continued. . .

Table 2-1. Front Panel Controls (Models 6014, 6015) - continued

Name	Function
Preset Switches Model 6014:	A single set of 10-digit thumbwheel switches permits selection of a single preset number.
Model 6015:	Two sets of 10-digit thumbwheel switches permit selection of two preset numbers, N_1 and N_2.
N SELECT Switch Model 6014:	A single three-position rotary switch permits selecting the sign of the preset number. In the ± position, the instrument performs the selected function when the absolute value of the accumulated sum reaches the absolute value of the preset number.
Model 6015:	A concentric three-position rotary switch permits independent selection of the signs of the two preset numbers. The ± position is as defined above for the Model 6014. The black inner switch selects the sign of N_1 while the white outer switch selectes the sign of N_2.
FUNCTION Selector Model 6014:	This is a four-position rotary switch. When the accumulated sum reaches the preset number the following functions are performed: a) RESET N: Resets to zero and continues to accumulate; accumulation is uninterrupted. An electrical signal having 150 ns duration is generated at instant of reset. Signal appears on Pin 7 of the remote connector. b) HOLD N: Accumulator stops counting. The preset sum is stored and displayed until instrument is reset.

continued. . .

Table 2-1. Front Panel Controls (Models 6014, 6015) - continued

Name	Function
FUNCTION Selector Model 6014 - cont.	c) N LIMIT: An electrical step output appears on Pin 7 of remote connector. The level remains until the instrument either is reset or again reaches the preset number while accumulating in the opposite sense. Accumulation is uninterrupted. d) REMOTE: Function is selected with contact closures to ground on the remote connector. Pin 9 on remote connector becomes ground. 1) RESET N - Ground Pin 11. 2) HOLD N - Ground Pin 10. 3) N LIMIT - Both Pins 10 and 11 are kept open.
Model 6015:	The FUNCTION selector is a six-position rotary switch. When the accumulated sum reaches a preset number, the following functions are performed: a) RESET N_1: When accumulated sum reaches N_1, the instrument resets to zero and continues to accumulate, uninterrupted. At instant of reset, an electrical signal having 150 ns duration is generated. Signal appears on Pin 7 of remote connector. b) RESET N_2: The above function is performed when the accumulated sum reaches N_2. The output signal appears on Pin 6 of the remote connector. c) HOLD N_1: When accumulated sum reaches N_1 accumulator stops counting. The preset sum is stored and displayed until instrument is reset. d) HOLD N_2: The above function is performed when the accumulated sum reaches N_2.

continued. . .

Table 2-1. Front Panel Controls (Models 6014, 6015) - continued

Name	Function
FUNCTION Selector Model 6015 - cont.	e) N_1 N_2 LIMITS: Electrical step outputs are generated when accumulator reaches N_1 and N_2. These levels remain until the instrument is reset or again reaches the preset numbers while accumulating in the opposite sense. The N_1 level appears on Pin 7 while the N_2 output level appears on Pin 6 of the remote connector. f) REMOTE: Function is selected with contact closures to ground on the remote connector. Pin 9 on remote connector becomes ground. 1) RESET N_1: Ground Pin 11. 2) RESET N_2: Ground Pin 13. 3) HOLD N_1: Ground Pin 10. 4) HOLD N_2: Ground Pin 12. 5) N_1 N_2 LIMITS: Pins 10, 11, 12, and 13 are kept open.

Table 2-2. Rear Panel Connectors

X and Y INPUT J1, J3 (Type BNC)	X and Y data is applied at these connectors.
Remote Connector J2 (36-Pin Amphenol 57-40360)	Provides remote selection of slope, FUNCTION, MODE, remote control and reset. Also provides N preset outputs (refer to Table 2-3).

2.3 REMOTE CONNECTOR J2

The REMOTE connector permits remote gating and reset, and selection of slope, function, and mode. In all cases, desired gating, reset, and selection requires only a contact closure to ground of the proper pin(s). The preset N output signal(s) also appear at the remote connector. Table 2-3 shows pin numbering on the remote connector.

Table 2-3. Models 6014 and 6015 Remote Connector Pin Numbers

Pin Number	Function	Pin Number	Function
1	X - slope select	19	Y - slope select
2	Ground	20	Ground
3	*	21	*
4	*	22	*
5	*	23	*
6	(N_2 output)	24	Ground - twisted with 6
7	N_1 output	25	Ground - twisted with 7
8	*	26	*
9	Ground when FUNCTION is REMOTE	27	*
		28	*
10	HOLD N_1 FUNCTION	29	*
11	RESET N_1 FUNCTION	30	*
12	(HOLD N_2 FUNCTION)	31	*
13	(RESET N_2 FUNCTION)		
14	*	32	Ground when GATE is OFF/REMOTE
15	Ground when MODE is REMOTE	33	GATE ON
16	X MODE	34	Sense Control
17	X+Y MODE	35	Ground
18	X-Y MODE	36	Remote Reset

* Not used in standard instrument.

( ) Not used in Model 6014.

2.4 OPERATING PROCEDURE

1) To turn the instrument on, set GATE switch to either ON or OFF/ REMOTE.

   a) ON: Count gate is OPEN. Instrument accumulates data appearing at X and Y inputs.

   b) OFF/REMOTE: GATE control is transferred to the remote connector. Providing Pin 33 on remote connector is not grounded, count gate is CLOSED.

2) Select individual positive or negative X and Y input slope triggering. Follow procedure outlined in Section 2.5.2 of Model 6013 manual.

3) Adjust individual X and Y input triggering levels. Follow procedure outlined in Section 2.5.1 of Model 6013 manual.

4) Select desired operating mode with MODE selector. If operating in X MODE, select the sense using procedure outlined in Section 2.5.3 of Model 6013 manual. If operating in REMOTE MODE, follow procedure outlined in Table 2-1 of Model 6013 manual under the REMOTE mode.

5) Select each digit of the preset number(s).

6) Select sign(s) of the preset number(s) with the N SELECT.

7) Set FUNCTION selector to the desired function. If operating in REMOTE, select function according to procedure outlined in Table 2-1 under FUNCTION selector; REMOTE.

8) When ready to accumulate, press RESET button. If remote reset is used, ground Pin 36 on remote connector.

SECTION 3

THEORY OF OPERATION

3.1 GENERAL

All operational boards present in the Model 6013 are present in the Models 6014 and 6015. These boards are located in the same positions as in the Model 6013. In addition, the Model 6014 has a single "preset" circuit board while the Model 6015 has two "preset" circuit boards.

3.2 THEORY OF OPERATION OF THE BASIC REVERSING ACCUMULATOR

The "basic reversing accumulator" section of the Models 6014 and 6015 (input amplifier, forward-reverse logic, accumulator control, and decimal counting units) is the same as for the Model 6013. Theory of Operation is described in Sections 3.1 through 3.6 of the Model 6013 manual. Block diagrams of the printed circuit boards present in the Models 6014 and 6015 are shown in Figure 3-1, a fold-out sheet at the end of this section.

3.3 PRESET BOARDS

3.3.1 General

The preset boards are used with the Models 6014 and 6015 Accumulators. The purpose of this board is to provide either a dc gate or reset trigger signal to the accumulator control whenever the accumulated sum reaches the preset limit. These signals correspond to the FUNCTION switch being in either the HOLD or RESET positions. The LIMIT position of the FUNCTION switch results in neither a gate nor reset trigger signal from the preset board. Thus, the operator can have the accumulator stop counting and hold the sum when the preset limit is reached, automatically reset to zero, or count beyond the preset limit.

A diagram of the inputs and outputs to preset board is shown in Figure 3-2. A logic diagram of preset board operation is shown in Figure 3-3.

3.3.2 DCU and Preset Select Switches

The bank of five preset select switches provides a negative-going output pulse (0 to -7 volts) to the preset board whenever the absolute value of the accumulator sum matches the preset number. Each preset switch recognizes the presence of its preset digit in its corresponding DCU by the simultaneous appearance of a signal on the correct dual decimal and odd-even lines. For example, Figure 3-4 shows the 10^1 preset switch at "0". When the 10^1 DCU registers "0", negative-going signals (0 to -6 volts) will appear on H and C. The output diodes in the bank of select switches perform as a negative zone AND gate (refer to Appendix A5). Therefore, an output to the preset board occurs only when all five DCU's simultaneously register their preset decimal digits.

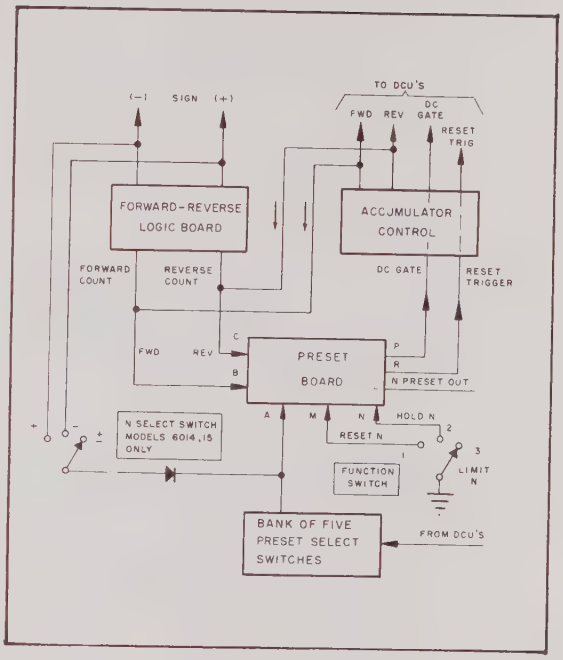


Fig. 3-2. Preset Boards Inputs and Outputs

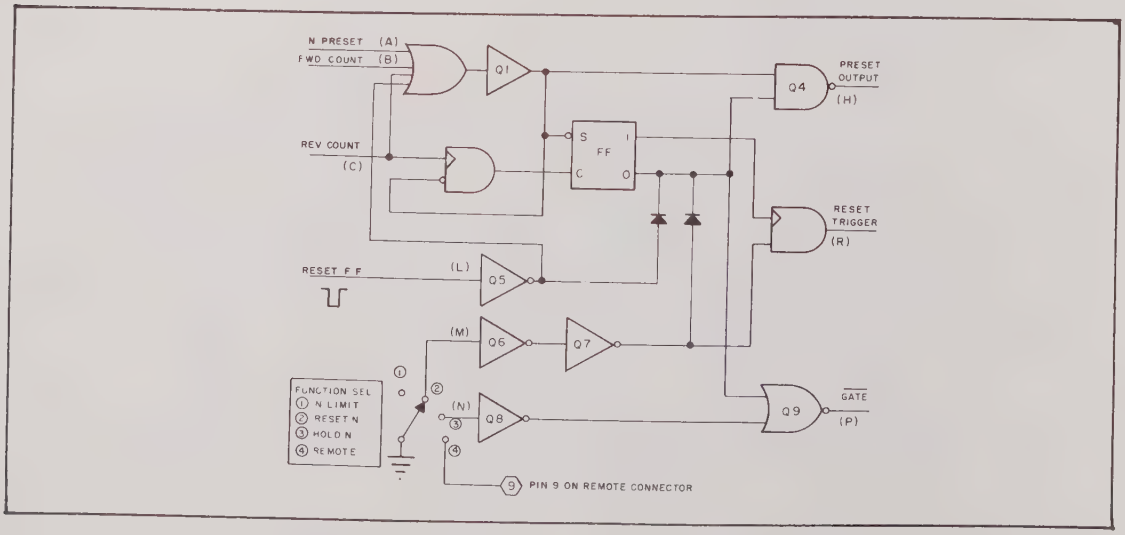


Fig. 3-3. Preset Board Logic Diagram

3.3.3 N-SELECT Switch

The N-SELECT switch selects the sign of the preset number. With the N-SELECT switch and diode connected into the coincidence AND gate as shown (Figure 3-4), the output of the preset switch bank is inhibited whenever the sign appearing in the accumulator is different than the sign of the preset number. Only when the sign of both the N-SELECT and accumulator display are the same will the voltage across the diode be sufficiently negative to ungate the coincidence pulse to the preset board. Therefore, the N-SELECT provides a gate control signal which maintains the coincidence gate "open" only when the signs of both N-SELECT and accumulator display are the same. Any difference in sign will keep the voltage across the diode at ground and the coincidence gate "closed". In the ± position, the N-SELECT switch relinquishes control of the AND gate, and a coincidence pulse ("magnitude of accumulator sum coincides with preset limit") is generated irrespective of sign.

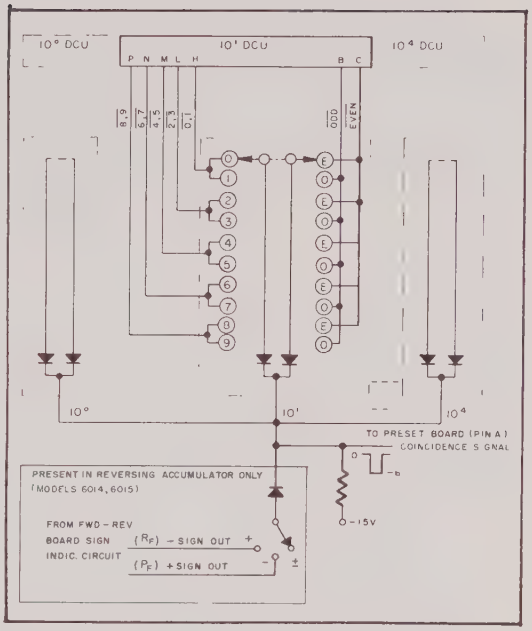


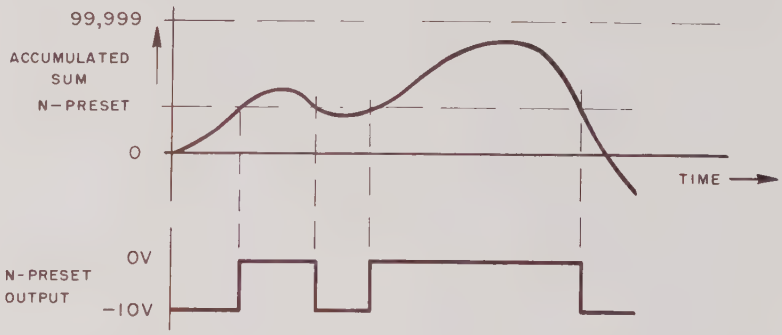
Fig. 3-4. Preset Select Switch Schematic

3.3.4 N-PRESET Out

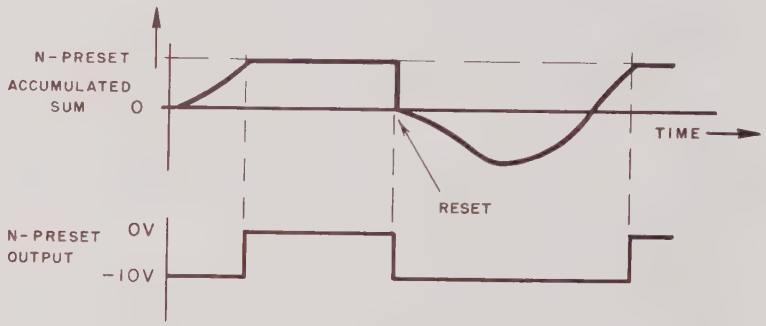
With the FUNCTION switch in the N-LIMIT position, the preset board provides a dc output level (0 volts) whenever the preset limit is exceeded. This dc level remains until the preset limit is again reached with a reverse pulse. It then returns to a negative voltage level (-10 volts) when the accumulator falls below the preset limit (Figure 3-5a).

With the FUNCTION switch in the HOLD-N position, the 0 volt dc level remains until the accumulator is reset to zero (Figure 3-5b).

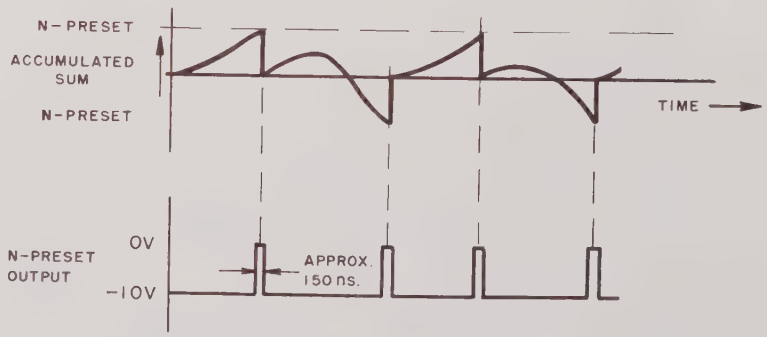
With the FUNCTION switch in the RESET position, the preset board provides a positive-going signal level (-10 volts to ground) each time the accumulator reaches the preset limit. This signal has a duration of approximately 150 nanoseconds (Figure 3-5c).



a) N-PRESET Output When FUNCTION Switch is in N-LIMIT Position. N-SELECT Switch is in + Position.



b) N-PRESET Output When FUNCTION Switch is in HOLD N Position. N-SELECT Switch is in + Position.



c) N-PRESET Output When FUNCTION Switch is in RESET N Position. N-SELECT Switch is in ± Position.

Fig. 3-5. N-PRESET Outputs

3.3.5 DC Gate and Reset Trigger

The gating signals and reset pulses are triggered with the "0" and "1" outputs from the flip-flop. The gating circuits for these two signals is controlled by the FUNCTION selector being in either the HOLD N or RESET N positions, respectively. As shown in Figure 3-3, the FUNCTION selector controls the NOR or AND output gates for the $\overline{\text{GATE}}$ or "reset trigger" signals in the open condition.

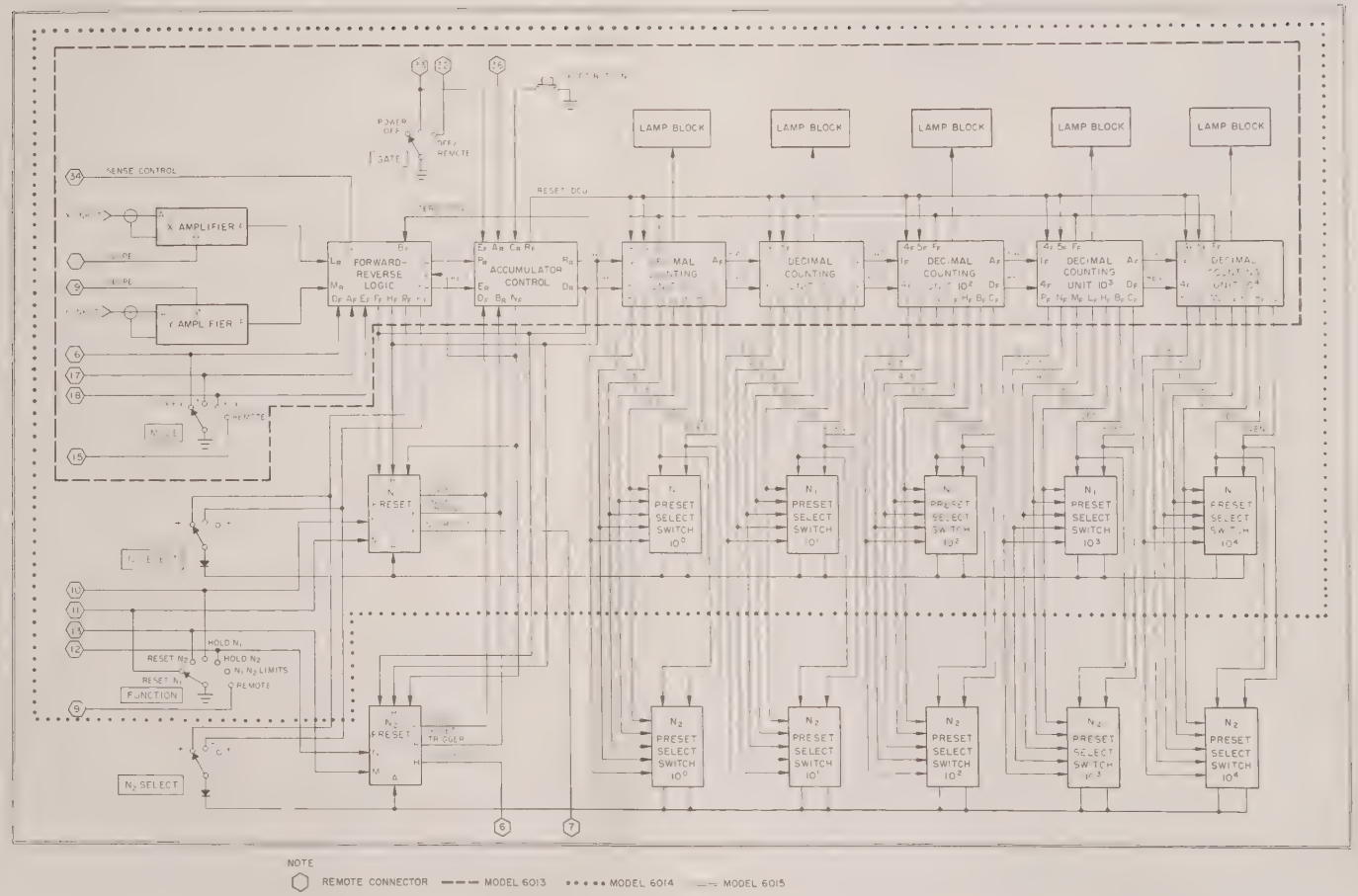


Fig. 3-1. Block Diagram

PART B

SECTION 4

SERVICING

4.1 GENERAL

Servicing information for the Models 6014 and 6015 is the same as for the Model 6013. Refer to Section 5 of the Model 6013 manual.

SECTION 5

PARTS LIST

NOTE: The following assemblies are present in the Models 6013, 6014 and 6015.

Assembly	Beckman Stock No.	Page
Input Amplifier Printed Circuit Board	887-425611	5-1
Forward Reverse Logic Printed Circuit Board	887-425255	5-3
Accumulator Control Printed Circuit Board	887-425470	5-6
Bi-Quinary DCU W/Readout	887-426102	5-9
Regulator Printed Circuit Board	887-423795	5-11
Power Supply Components		5-12
Miscellaneous Parts		5-13

Detail No.	Beckman Stock No.	Description	Qty. / Ass'y
	887-425611	INPUT AMPLIFIER P. C. BOARD	2
C1	633-804715	CAPACITOR, F. Cerm. .01μf, 50V	5
C2	633-811294	CAPACITOR, F. Mica 1. 5pf, 600V	1
C3	633-838425	CAPACITOR, F. Cerm. 22pf, 500V	1
C4 thru C7		Same as C1	
CR1	755-420893	DIODE, 893	8
CR2		Same as CR1	
CR3	755-815561	DIODE, IN3064 (CD6111)	4
CR4		Same as CR3	
CR6 thru CR9		Same as CR1	
CR10 & CR11		Same as CR3	
CR12 & CR13		Same as CR1	
Q1	755-425735	TRANSISTOR, Special	5
Q2		Same as Q1	

Detail No.	Beckman Stock No.	Description	Qty./ Ass'y
Q3	755-838784	TRANSISTOR, 2N3565	2
Q4		Same as Q3	
Q7 thru Q9		Same as Q1	
Q10	755-838105	TRANSISTOR, 2N3638	1
R1	601-823387	RESISTOR, F. Comp., 47Ω, 1/4W, 5%	3
R2	601-822301	RESISTOR, F. Comp. ,15K, 1/4W, 5%	4
R3	601-822326	RESISTOR, F. Comp. 1.2K, 1/4W, 5%	3
R4		Same as R2	
R5	601-823386	RESISTOR, F. Comp, 39Ω, 1/4W, 5%	2
R6		Same as R5	
R7	601-822331	RESISTOR, F. Comp, 8.2K, 1/4W, 5%	2
R8	601-823391	RESISTOR, F. Comp, 150Ω, 1/4W, 5%	2
R9		Same as R34	
R10		Same as R7	
R11		Same as R2	
R12	611-826874	RESISTOR, Var. 10K, W.W.	1
R13	601-823902	RESISTOR, F. Comp., 47K, 1/4W, 5%	1
R14	601-015082	RESISTOR, F. Comp., 200K, 1/2W, 5%	1
R15	601-822334	RESISTOR, F. Comp. 22K, 1/4W, 5%	1
R16	601-823908	RESISTOR, 220K, 1/4W, 5%	1
R17	601-822324	RESISTOR, F. Comp. 10K, 1/4W, 5%	1
R18		Same as R2	
R19	601-822295	RESISTOR, F. Comp. 2.7K, 1/4W, 5%	1
R20		Same as R1	
R28		Same as R8	
R29 & R30		Same as R3	
R31	601-822544	RESISTOR, F. Comp, 1.8K, 1/4W, 5%	2
R32		Same as R31	
R33	601-822369	RESISTOR, F. Comp. 680Ω, 1/4W, 5%	1

Detail No.	Beckman Stock No.	Description	Qty./ Ass'y.
R34	601-079172	RESISTOR, F. Comp., 820Ω, 1/2W, 5	2
R35	601-822297	RESISTOR, F. Comp, 4.7K, 1/4W, 5%	3
R36 & R37		Same as R35	
R38		Same as R1	
R39	601-822335	Res. 27K, 1/4W, 5%	1
	693-425573	Printed Circuit Board Amplifier	1
	887-425255	FORWARD REVERSE LOGIC P.C. BD.	1
C1	633-838426	Cap. F. Cerm., 33pf, 500V, 10%	9
C3 thru C10		Same as C1	
C11	633-804715	Cap. F. Cerm., .01mf, 50V	4
C12 thru C14		Same as C11	
CR1	755-815561	Diode, Silicon, CD6111	24
CR7	755-402107	Diode, Special, IN95	1
CR8	755-420893	Diode, Special	36
CR9 thru CR17		Same as CR8	
CR18 thru CR22		Same as CR1	
CR23 thru CR26		Same as CR8	
CR27 thru CR29		Same as CR1	
CR31 thru CR35		Same as CR8	
CR37 thru CR39		Same as CR1	
CR40 thru CR42		Same as CR8	
CR43		Same as CR1	
CR44 & CR45		Same as CR8	
CR46 thru CR49		Same as CR1	

Detail No.	Beckman Stock No.	Description	Qty./ Ass'y
CR50 & CR51		Same as CR8	
CR52 thru CR54		Same as CR1	
CR55 & CR56		Same as CR8	
CR57 & CR58		Same as CR1	
CR59 thru CR66		Same as CR8	
CR67 & CR68		Same as CR1	
Q1	755-425735	Transistor, Special	15
Q2 thru Q9		Same as Q1	
Q10	755-422494	Transistor, Special	2
Q11		Same as Q10	
Q12 thru Q17		Same as Q1	
R1	601-822297	Res. F. Comp, 4.7K, 1/4W, 5%	40
R2		Same as R1	
R3	601-822335	Res. F. Comp, 27K, 1/4W, 5%	5
R4		Same as R1	
R5	601-823395	Res. F. Comp. 470Ω, 1/4W, 5%	1
R6 & R7		Same as R1	
R8		Same as R3	
R9		Same as R1	
R10	601-822369	Res. F. Comp., 680Ω, 1/4W, 5%	2
R11 & R12		Same as R1	
R13		Same as R3	
R14		Same as R1	
R16	601-822324	Res. F. Comp. 10K, 1/4W, 5%	10
R17	601-822326	Res. F. Comp. 1.2K, 1/4W, 5%	1
R18		Same as R10	
R19 & R20		Same as R1	

Detail No.	Beckman Stock No.	Description	Qty./ Ass'y
R21		Same as R3	
R22 & R23		Same as R1	
R24		Same as R3	
R25 & R26		Same as R1	
R27	601-822527	Res. F. Comp. 1.5K, 1/4W, 5%	4
R28		Same as R1	
R29		Same as R27	
R30		Same as R1	
R34	601-822798	Res. F. Comp. 68K, 1/4W, 5%	2
R37		Same as R34	
R39		Same as R27	
R40		Same as R16	
R41	601-823391	Res. F. Comp. 150Ω, 1/4W, 5%	2
R42		Same as R27	
R43		Same as R16	
R44	601-822301	Res. F. Comp. 15K, 1/4W, 5%	1
R45		Same as R41	
R46	601-822299	Res. F. Comp. 6.8K, 1/4W, 5%	16
R47 thru R50		Same as R46	
R51		Same as R16	
R52 & R53		Same as R1	
R54 thru R56		Same as R46	
R57		Same as R16	
R58 & R59		Same as R1	
R60 thru R62		Same as R46	
R63		Same as R16	
R64 thru R66		Same as R1	

Detail No.	Beckman Stock No.	Description	Qty. / Ass'y
R67		Same as R16	
R68		Same as R46	
R69 thru R71		Same as R1	
R72		Same as R46	
R73		Same as R16	
R74 thru R77		Same as R1	
R78		Same as R46	
R79		Same as R16	
R80 thru R83		Same as R1	
R84		Same as R46	
R85		Same as R16	
R86 thru R88		Same as R1	
R89		Same as R46	
R90 & R91		Same as R1	
	693-424489	Printed Circuit Bd.	1
	887-425470	ACCUMULATOR CON. P.C. BOARD	1
C1	637-824028	Cap. 1000pf, 300V, 5%	1
C2	633-836932	Cap. 100pf, 500V, 10%	1
C3	633-804715	Cap. .01μf, 50V	5
C4		Same as C3	
C5	633-838426	Cap. 33pf, 500V, 10%	8
C6		Same as C5	
C7	633-838427	Cap. 15pf, 500V, 10%	1
C8		Same as C5	
C9	633-839568	Cap. 47pf, 500V, 10%	2
C10		Same as C5	
C11		Same as C9	
C13	633-838425	Cap. 22pf, 500V, 10%	2

Detail No.	Beckman Stock No.	Description	Qty./ Ass'y
C14 & C15		Same as C5	
C16		Same as C3	
C17		Same as C13	
C18 & C19		Same as C5	
C20 & C21		Same as C3	
CR1	755-815561	DIODE, 1N3064 (CD6111)	10
CR2	755-420893	DIODE, Special "893"	7
CR3		Same as CR1	
CR4		Same as CR2	
CR5		Same as CR1	
CR6		Same as CR2	
CR7 & CR8		Same as CR1	
CR9 & CR10		Same as CR2	
CR11 & CR12		Same as CR1	
CR13 & CR14		Same as CR2	
CR15		Same as CR1	
CR16	755-404593	DIODE, Special	2
CR17		Same as CR16	
CR18 & CR19		Same as CR1	
Q1	755-425735	TRANSISTOR, Special	12
Q2 thru Q5		Same as Q1	
Q6	755-419596	TRANSISTOR, Special	1
Q7	755-817964	TRANSISTOR, 2N1420	1
Q8 thru Q10		Same as Q1	
Q11	755-422494	TRANSISTOR, Special	1

Detail No.	Beckman Stock No.	Description	Qty./ Ass'y
Q12 thru Q15		Same as Q1	
R1	601-822297	RESISTOR, 4.7K, 1/4W, 5%	12
R2 thru R4		Same as R1	
R6	601-823397	RESISTOR, 5.6K, 1/4W, 5%	1
R7	601-822324	RESISTOR, 10K, 1/4W, 5%	3
R8	601-822527	RESISTOR, 1.5K, 1/4W, 5%	3
R9		Same as R1	
R10	601-822303	RESISTOR, 18K, 1/4W, 5%	2
R11	601-822544	RESISTOR, 1.8K, 1/4W, 5%	3
R12	601-823393	RESISTOR, 270 ohm, 1/4W, 5%	2
R13	601-822308	RESISTOR, 1K, 1/4W, 5%	1
R14	601-822296	RESISTOR, 3.3K, 1/4W, 5%	2
R15		Same as R8	
R16	601-822331	RESISTOR, 8.2K, 1/4W, 5%	3
R17		Same as R8	
R18		Same as R14	
R19		Same as R1	
R20		Same as R12	
R21	601-822328	RESISTOR, 2.2K, 1/4W, 5%	3
R22	601-822460	RESISTOR, 3.9K, 1/4W, 5%	3
R23		Same as R10	
R24	601-822299	RESISTOR, 6.8K, 1/4W, 5%	2
R25		Same as R21	
R26		Same as R22	
R27		Same as R1	
R28	601-822301	RESISTOR, 15K, 1/4W, 5%	3
R29		Same as R1	
R30		Same as R21	
R31		Same as R24	
R32	601-823394	RESISTOR, 330ohm, 1/4W, 5%	1

Detail No.	Beckman Stock No.	Description	Qty./ Ass'y
R33		Same as R7	
R34	601-822798	RESISTOR, 68K, 1/4W, 5%	1
R35	601-823391	RESISTOR, 150 ohm, 1/4W, 5%	1
R36	601-823395	RESISTOR, 470 ohm, 1/4W, 5%	4
R37		Same as R16	
R38		Same as R28	
R39		Same as R11	
R40		Same as R1	
R41	601-823903	RESISTOR, 56K, 1/4W, 5%	2
R42		Same as R36	
R43	601-822371	RESISTOR, 390 ohm, 1/4W, 5%	2
R44		Same as R36	
R45		Same as R16	
R46		Same as R28	
R47		Same as R1	
R48		Same as R11	
R49		Same as R41	
R50		Same as R36	
R51		Same as R43	
R52	601-015038	RESISTOR, 1K, 1/2W, 5%	1
R53 & R54		Same as R1	
R55		Same as R7	
R56		Same as R22	
R57	601-822326	RESISTOR, 1.2K, 1/4W, 5%	2
R58		Same as R57	
	693-425017	Printed Circuit, Accum. Cont. P.C. Bd.	1
	887-426102	BI-QUINARY DCU W/READOUT	5
C1	633-839570	CAP., 39pf, 500V, 10%	4
C2 thru C4		Same as C1	
C5		Same as C6	

Detail No.	Beckman Stock No.	Description	Qty./ Ass'y
C6	633-839569	CAP. 10pf, 500V, 10%	4
C7 & C8		Same as C6	
C9	633-839568	CAP. 47pf, 500V, 10%	10
C10 thru C18		Same as C9	
C19	633-804715	CAP. .01μf, 50V	3
C20 & C21		Same as C19	
CR1	755-815561	DIODE, (CD6111)	22
CR2 thru CR20		Same as CR1	
CR25	755-402107	DIODE, Special	10
CR26 thru CR34		Same as CR25	
CR49 & CR50		Same as CR1	
Q1	755-425735	TRANSISTOR, Special	11
Q2 thru Q11		Same as Q1	
Q13	755-422494	TRANSISTOR, Special	6
Q14	755-817964	TRANSISTOR, 2N1420	2
Q15		Same as Q14	
Q17		Same as Q13	
Q19		Same as Q13	
Q21		Same as Q13	
Q23		Same as Q13	
Q25		Same as Q13	
R1	601-015443	RESISTOR, 330Ω, 1/2W, 5%	1
R2	601-822299	RESISTOR, 6.8K, 1/4W, 5%	2
R3		Same as R2	
R8	601-823381	RESISTOR, 15Ω, 1/4W, 5%	1
RM1	885-425909	RESISTOR MODULE	5
RM2 thru RM5		Same as RM1	
RM6	885-425908	RESISTOR MODULE	2

Detail No.	Beckman Stock No.	Description	Qty./ Ass'y
RM7		Same as RM6	
RM8	885-425906	RESISTOR MODULE	6
RM9	885-425907	RESISTOR MODULE	1
RM10 thru RM14		Same as RM8	
	693-426036	Printer Circuit Bd., Bi-Qui W/RO	1
	887-423795	REGULATOR P.C. BOARD	1
C1	631-837782	Cap. Elect. 1μf, 50V, ±20%	3
C2 & C3		Same as C1	
CR1	755-404593	DIODE, Special	3
CR2	755-824951	DIODE, Zener 1N754	1
CR3		Same as CR1	
CR5 & CR6		Same as CR1	
Q1	755-817210	TRANSISTOR, 2N1304	3
Q2	755-836485	TRANSISTOR, 2N2374	3
Q3	755-800398	TRANSISTOR, 2N404	3
Q4		Same as Q1	
Q5		Same as Q2	
Q6		Same as Q3	
Q7		Same as Q1	
Q8		Same as Q2	
Q9		Same as Q3	
R1	601-008080	RES. Comp., 2.2K, 1/2W, 10%	2
R2	601-822327	RES. Comp., 220Ω, 1/4W, 5%	3
R3	601-812856	RES. Comp., 2.2K, 1/4W, 10%	2
R4	601-823111	RES. Comp. 1K, 1/4W, 10%	1
R5	601-822369	RES. Comp. 680Ω, 1/4W, 5%	1
R6	611-812861	RES. Var. W. W. 200 ohm	2
R7	601-823396	RES. Comp. 560Ω, 1/4W, 5%	1
R8		Same as R1	

Detail No.	Beckman Stock No.	Description	Qty./ Ass'y
R9		Same as R2	
R11		Same as R3	
R12	601-822308	RES. Comp. 1K, 1/4W, 5%	2
R13	601-822306	RES. Comp. 820Ω, 1/4W, 5%	2
R14		Same as R6	
R15		Same as R13	
R16	601-008083	RES. Comp. 3.9K, 1/2W, 10%	1
R17		Same as R2	
R18	601-823926	RES. Comp. 56Ω, 1/4W, 10%	1
R19	601-823108	RES. Comp. 10K, 1/4W, 10%	1
R20	601-015045	RES. Comp. 2.7K, 1/2W, 5%	1
R21	611-815619	RES. Var. W. W. 500 ohm	1
R22	601-822326	RES. Comp. 1.2K, 1/4W, 5%	1
R23		Same as R12	
R24	601-822297	RES. Comp. 4.7K, 1/4W, 5%	1
R25	601-822544	RES. Comp. 1.8K, 1/4W, 5%	1
	693-423913	Printed Circuit Board, Regulator	1
		POWER SUPPLY COMPONENTS	1
C1	631-423957	CAPACITOR, 920pf, 50V	1
C2	631-423959	CAPACITOR, 3000pf, 25V	1
C3	631-423958	CAPACITOR, 1800pf, 50V	1
CR1	774-824972	BRIDGE RECTIFIER	2
CR2	774-824971	BRIDGE RECTIFIER	1
CR3		Same as CR1	
E1	691-836661	BLOCK, TERMINAL (8 pos.)	1
E2	691-836659	BLOCK, TERMINAL (2 pos.)	1
T1	792-423956	TRANSFORMER, POWER	1
XA1	680-824871	CONNECTOR, 15 PIN (CINCH)	1
L1	795-423953	INDUCTOR	1
L2	795-423954	INDUCTOR	1
L3	795-423955	INDUCTOR	1
77	771-423828	FILTER LINE	1
	327-419568	P.C. BD. SUPPORT, MOD.	2

Detail No.	Beckman Stock No.	Description	Qty./ Ass'y
		MISCELLANEOUS PARTS	
	449-426138	Front Panel	1
	327-424293	Switch Bracket	1
	704-838151	Switch (RESET)	1
	711-425471	Switch (GATE)	1
	711-425917	Switch (FUNCTION) (6014 & 6015)	1
	711-425917	Switch (MODE)	1
	711-425917	N Select Switch (6014 only)	1
	711-425919	N_1 N_2 Select Switch (6015 only)	1
	010-425621	Bottom Cover	1
	297-426016	Top Cover	1
	115-425594	Stud Ass'y (CAMLOC #2753-5)	1
	443-425429	Front Panel Readout (6013 only)	1
	443-425430	Front Panel Readout (6014 only)	1
	443-425431	Front Panel Readout (6015 only)	1
	433-423456	Left Dress Panel	1
	443-425450	Right Front Dress Panel (6013 only)	1
	443-425451	Right Front Dress Panel (6014 only)	1
	443-425452	Right Front Dress Panel (6015 only)	1
	433-420427	Right Dress Panel	1
	716-838152	Reset Lens Cap Ass'y	1
	325-420982	Knob	3
	330-420770	Handle	2
	858-425732	Extension Board	2
	010-425669	Lamp Block & Bezel Ass'y	1
	349-423453	Right Side Panel	1
	349-423451	Left Side Panel	1
	327-423740	Connector Brackets	4
	680-424115	P. C. Board Connectors (Dual)	10
	680-823481	P. C. Board Connectors (Single) (6013 only)	8
	680-823481	P. C. Board Connectors (Single) (6014 only)	9

Detail No.	Beckman Stock No.	Description	Qty./ Ass'y
	680-823481	P. C. Board Connectors (Single) (6015 only)	10
	433-425483	Rear Panel	1
	349-420000	Rear Trim	2
	161-421927	Fan Spacer	4
	855-424415	Power Supply Ass'y	1
	010-421881	Fan & Shroud Ass'y	1
	664-812450	Line Cord	1
	735-007268	Fuse Holder	1
	697-420945	Lamp Block Connector Ass'y	6
	731-801567	Fuse, 1.5 amp. Slo Blo	1
	010-423797	Chassis	1
	670-806738	BNC Connectors	1
	672-824764	36 Pin Amphenol	1

NOTE: The following assemblies are present in the Models 6014 and 6015.

Assembly	Beckman Stock No.	Page
Preset Printed Circuit Board	887-426025	5-15

Detail No.	Beckman Stock No.	Description	Qty./ Ass'y
	887-426025	PRESET BOARD COMPONENT LAYOUT	1 or 2
C1	633-839568	CAP. 47 pf 500V, 10%	1
C2	633-804715	CAP. .01μf, 50V	3
C3	633-838426	CAP. 33pf 500V, 10%	3
C4	Same as C3		
C5	633-836931	CAP. 150pf 500V	1
C6		Same as C2	
C7	633-838425	CAP 22pf	1
C8		Same as C3	
C9		Same as C2	
CR1	A755-420893	DIODE, Special	6
CR2 thru CR17		Same as CR1	
R1	601-822301	RESISTOR, 15K, 1/4W, 5%	2
R2	601-823395	RESISTOR, 470Ω, 1/4W, 5%	3
R3		Same as R2	
R4	601-822369	RESISTOR, 680Ω, 1/4W, 5%	1
R5	601-822527	RESISTOR, 1.5K, 1/4W, 5%	2
R6	601-822297	RESISTOR, 4.7K, 1/4W, 5%	14
R7	601-822299	RESISTOR, 6.8K, 1/4W, 5%	2
R8	601-822303	RESISTOR, 18K, 1/4W, 5%	1
R9		Same as R2	
R10	601-823396	RESISTOR, 560Ω, 1/4W, 5%	2
R11		Same as R6	
R12	601-822335	RESISTOR, 27K, 1/4W, 5%	5
R13		Same as R6	
R14		Same as R12	
R15		Same as R10	

Detail No.	Beckman Stock No.	Description	Qty./ Ass'y
R16	601-822328	RESISTOR, 2.2K, 1/4W, 5%	1
R17		Same as R6	
R18	601-822531	RESISTOR, 68K, 1/4W, 5%	1
R19		Same as R5	
R20	601-822296	RESISTOR, 3.3K, 1/4W, 5%	1
R21		Same as R6	
R22		Same as R12	
R23	601-822295	RESISTOR, 2.7K, 1/4W, 5%	2
R24 thru R27		Same as R6	
R28		Same as R12	
R29		Same as R6	
R30	601-822324	RESISTOR, 10K, 1/4W, 5%	1
R31 & R32		Same as R6	
R33		Same as R7	
R34		Same as R6	
R35		Same as R12	
R36		Same as R23	
R37		Same as R6	
R38		Same as R1	
Q1	A755-425735	TRANSISTOR, Spec.	5
Q2 & Q3		Same as Q1	
Q4	A755-422494	TRANSISTOR, Spec.	1
Q5		Same as Q1	
Q6	755-838105	TRANSISTOR, 2N3638	3
Q7 & Q8		Same as Q6	
Q9		Same as Q1	

LOGIC SYMBOLS AND TYPICAL CIRCUITS

A.1 GENERAL

This section defines the logic symbols used in this manual. Typical circuit configurations are shown with each symbol. Actual circuits used in the instrument may be modifications of these typical circuits.

A.2 AND and OR Gates

The AND gate is a multiple input circuit which requires all inputs to be simultaneously present in order to produce an output.

A typical resistor-diode and capacitor-coupled AND gate is shown in Figure A-1.

The OR gate requires the presence of a single input in order to produce an output. A typical resistor-diode OR gate is shown in Figure A-2.

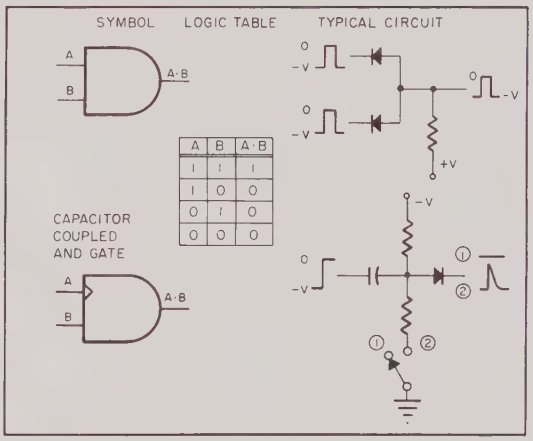


Fig. A-1. Standard AND and Capacitor-Coupled AND Gates

A.3 NAND Gate

The NAND gate is a multiple input circuit which requires all inputs to be logic "1" in order to produce a logic "0" output. A typical NAND gate circuit is shown in Figure A-3.

A.4 NOR Gate

The NOR gate is a multiple input circuit which requires all inputs to the gate to be logic "0" to

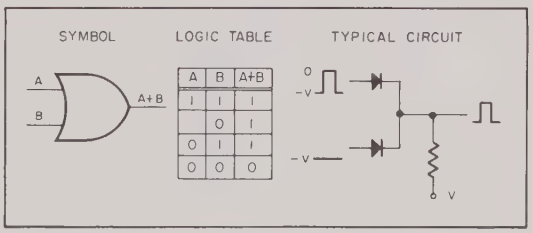


Fig. A-2. Typical Positive Zone OR Gate

produce a logic "1" output. A typical NOR gate circuit is shown in Figure A-4.

A.5 POSITIVE and NEGATIVE ZONE LOGIC

Unless stated otherwise, all logic symbols used in this manual refer to positive zone logic. Positive and negative zone logic are defined as follows.

1) Positive Zone Logic:

When input pulses to logic gates are "positive true" (-V of ground) and logic levels are -V = logic "0" and 0V = logic "1", it is often convenient to use "positive zone" logic. When logic description is referred to the positive zone, it is understood that all Boolean equations and logic symbols refer to these logic levels.

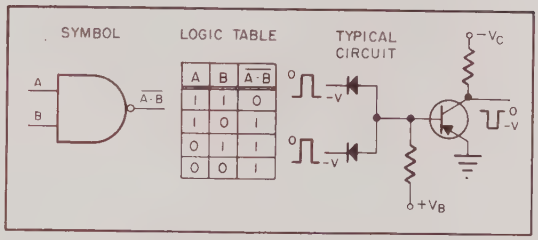


Fig. A-3. Typical Positive Zone NAND Gate

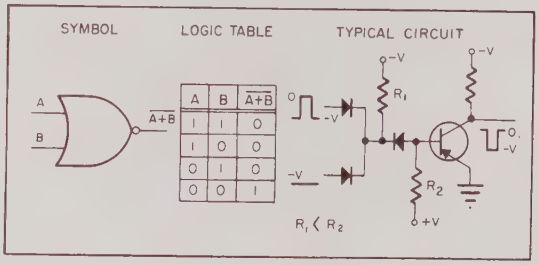


Fig. A-4. Typical Positive Zone NOR Gate

2) Negative Zone Logic:

When input pulses to logic gates are "negative true" (ground to -V) and logic levels are -V = logic "1" and 0V = logic "0", it is often convenient to use "negative zone" logic. When logic description is referred to the negative zone, it is understood that all Boolean equations and logic symbols refer to these logic levels.

Circuits used for AND gates in the positive zone become OR gates in the negative zone, and vice versa. Likewise, circuits used for NAND gates in the positive zone become NOR gates in the negative zone, and vice versa.

Figure A-5 shows typical AND and OR gates in negative zone logic.

A. 6 INVERTERS and EMITTER FOLLOWERS

Logic inverting circuits provide a method of converting a logic "0" to a logic "1" and vice versa. Figure A-6 shows the inversion operation and a typical inverting circuit.

An emitter follower circuit is represented by the ▷ symbol. This circuit is so named because the output at the emitter "follows" the input in phase. This circuit may be used as a current amplifier or as a coupling element.

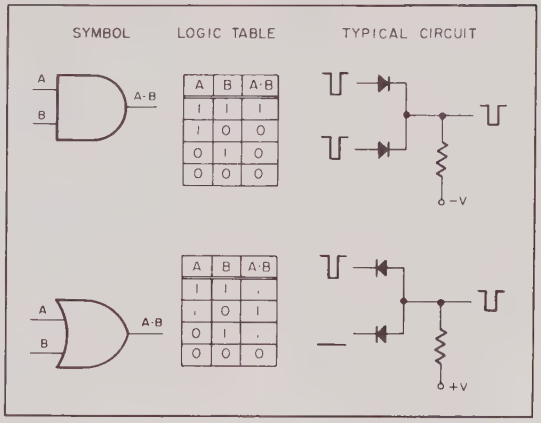


Fig. A-5. Typical AND and OR Gates in Negative Zone Logic

A. 7 BINARIES

The bistable multivibrator, or "flip-flop", is characterized by having two stable states, logic "1" or logic "0". Since both states are stable, the binary is commonly used in memory circuits, counting circuits, and shift registers.

A typical binary is shown in Figure A-7. In the usual configuration, there are two input lines: "set" and "clear". Signals appearing on these lines result in a logic "1" or logic "0" at the output. A complementary output line is also available for use.

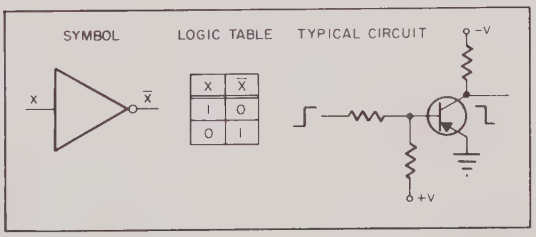


Fig. A-6. Typical Inversion Operation and Circuit

A. 8 SINGLE SHOTS

The monostable multivibrator, or "single-shot" is characterized by having a single stable state. When energized by an input signal the circuit is "excited" to its non-stable state. It remains in this state for a

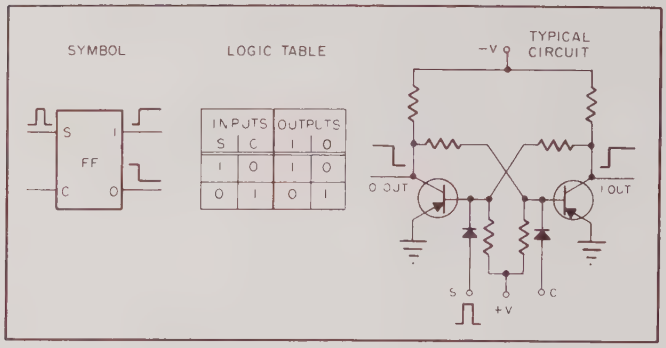


Fig. A-7. Typical Binary

predetermined time, then returns to the stable state. For this reason, the single shot is often used to provide output pulses having a fixed duration. A typical single shot is shown in Figure A-8.

A.9 INVERTED TRUE INPUTS

When one input to a logic circuit requires a negative true signal where a positive true signal is usually required, a "not" (o) indication is shown at the particular input terminal of the logic symbol.

Figure A-9 shows a capacitor-coupled AND gate requiring a logic "0" gate control voltage level to produce a positive true output. The same principle applies to all other logic symbols shown with the "not" input.

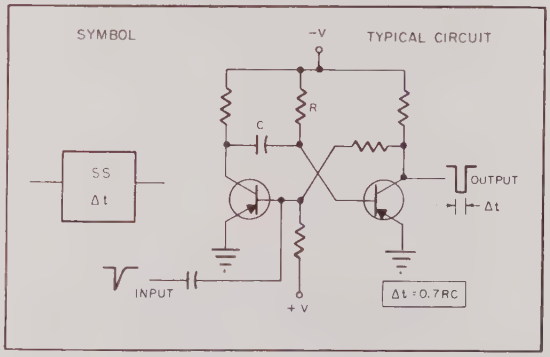


Fig. A-8. Typical Single Shot

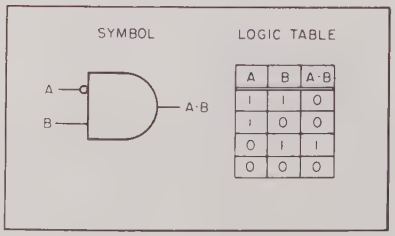
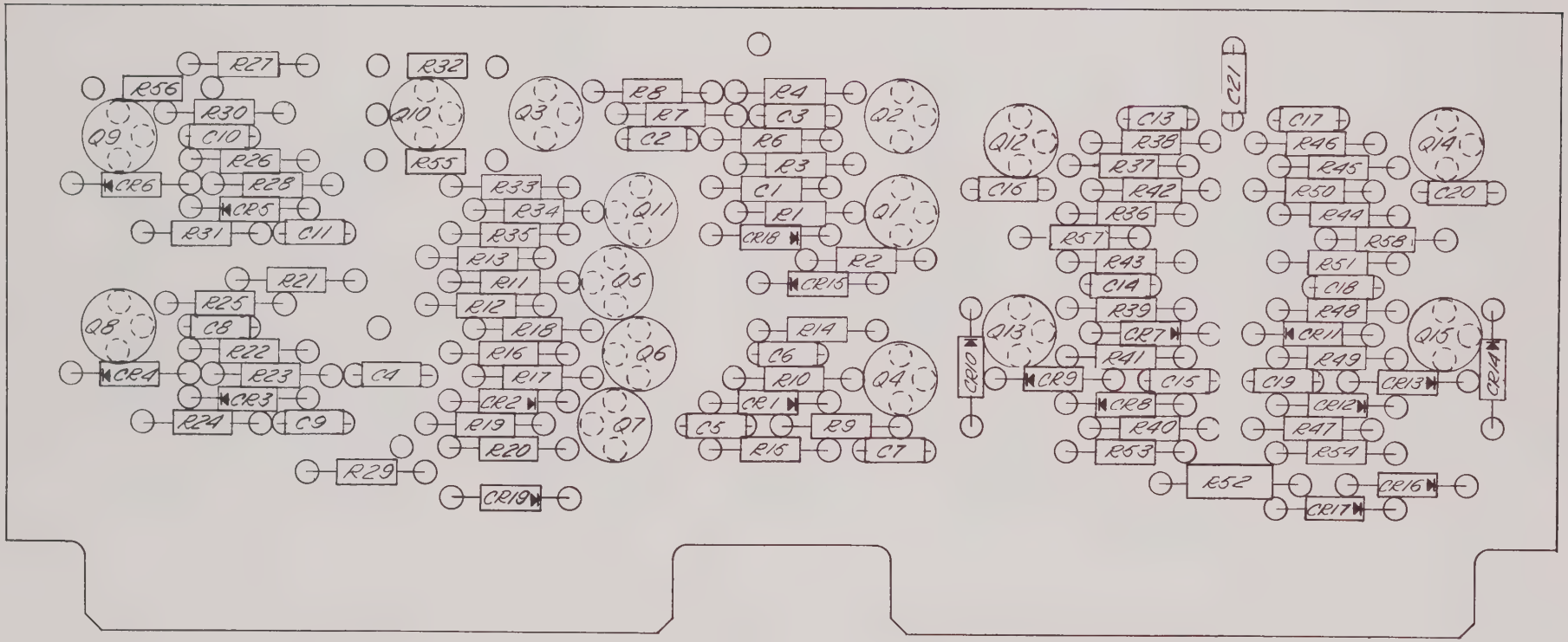


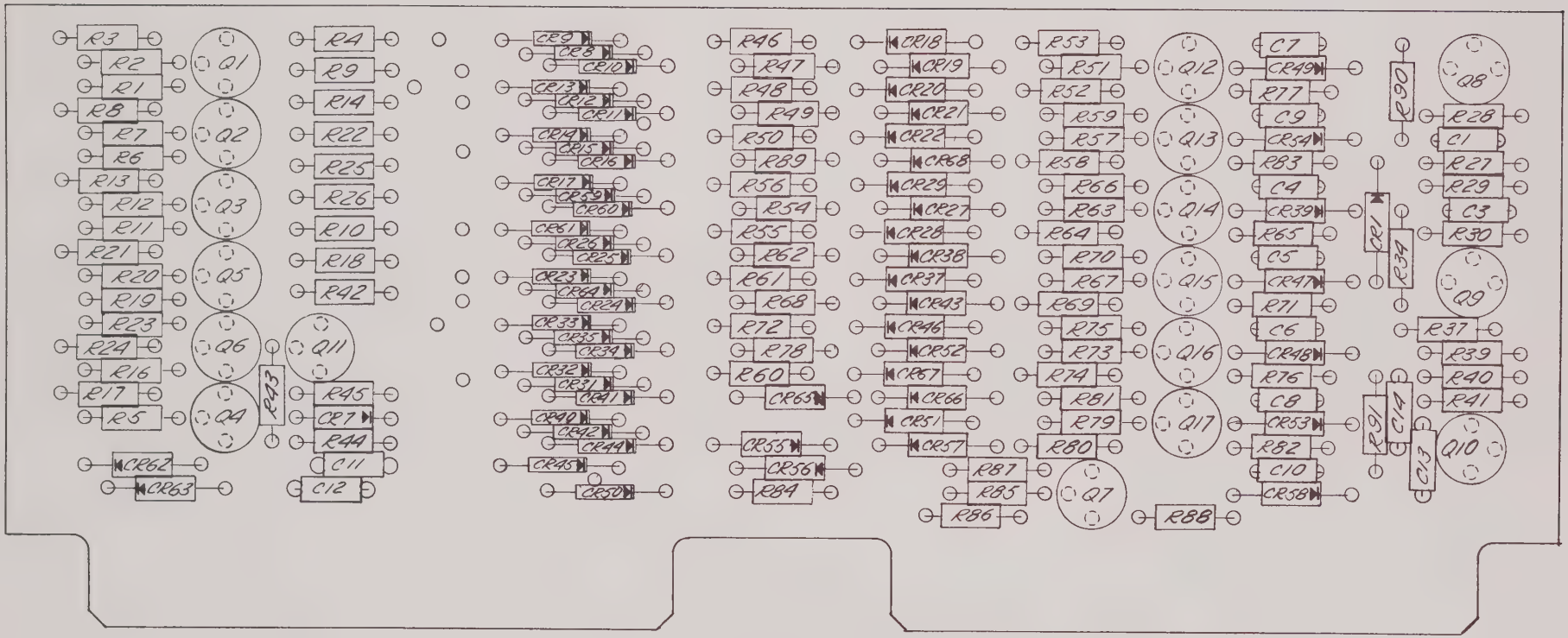
Fig. A-9. AND Gate Using Inverted Control Voltage Level



Accumulator Control P.C. Board Component Layout

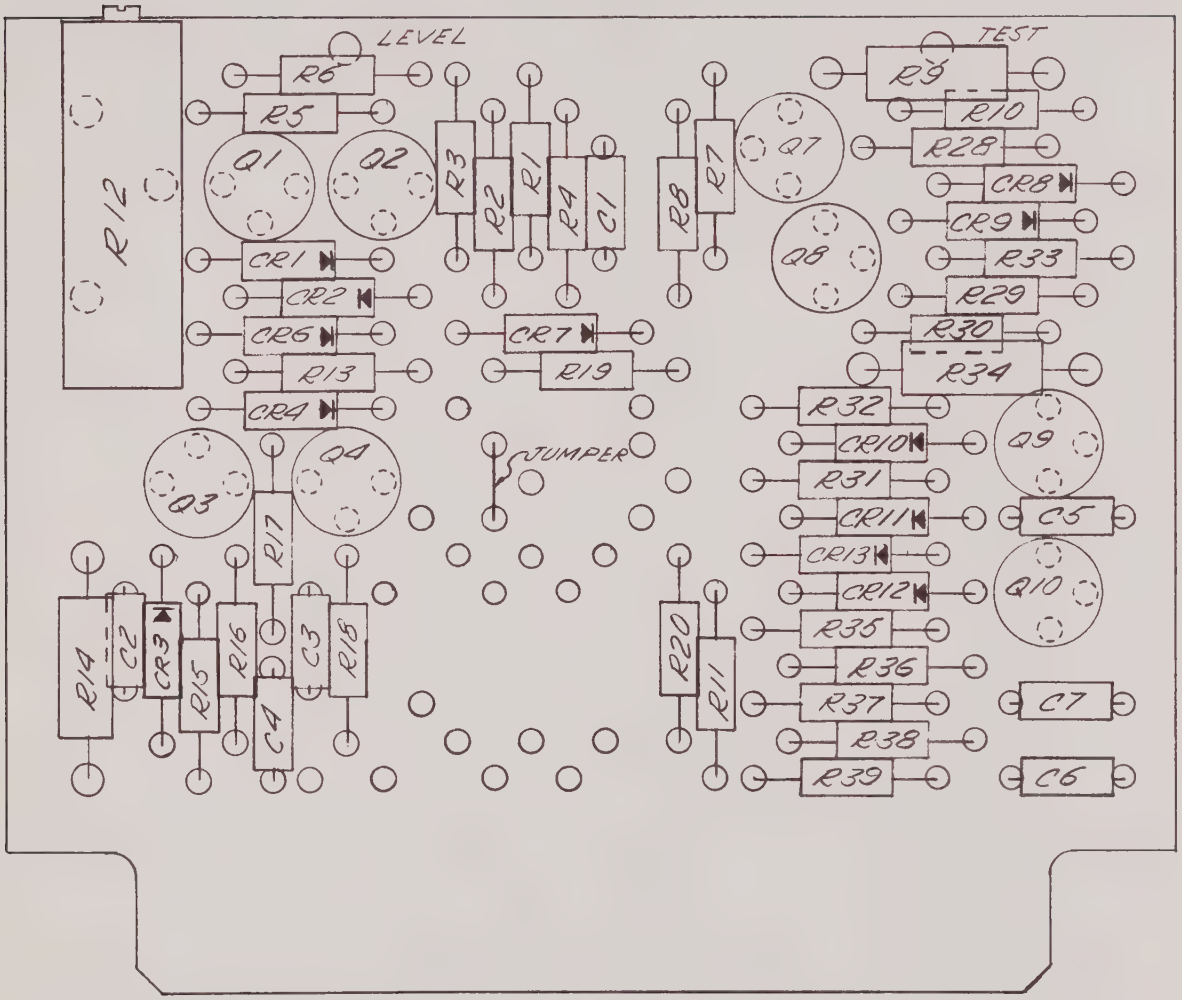
Models 6003, 04, 05; 6013, 14, 15
D-425470-Rev. B
August 1965

Beckman

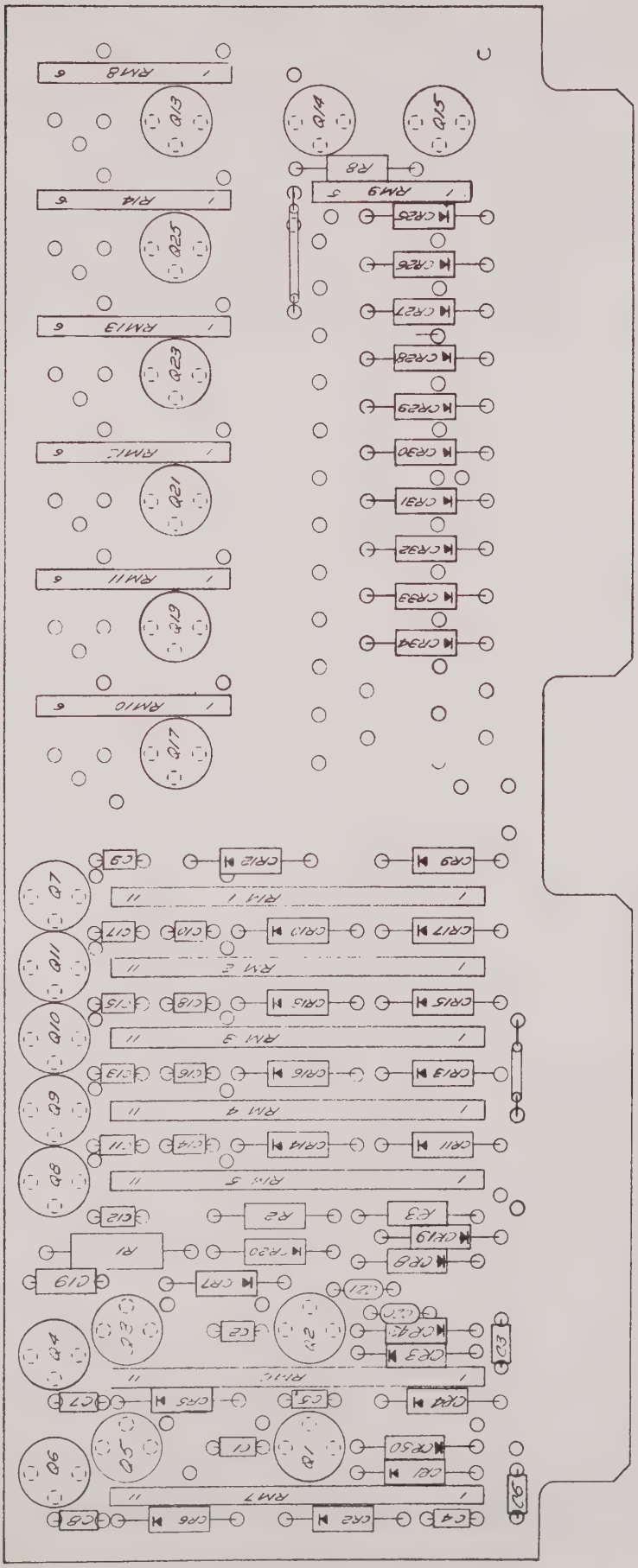


Forward-Reverse P.C. Board Component Layout

Beckman



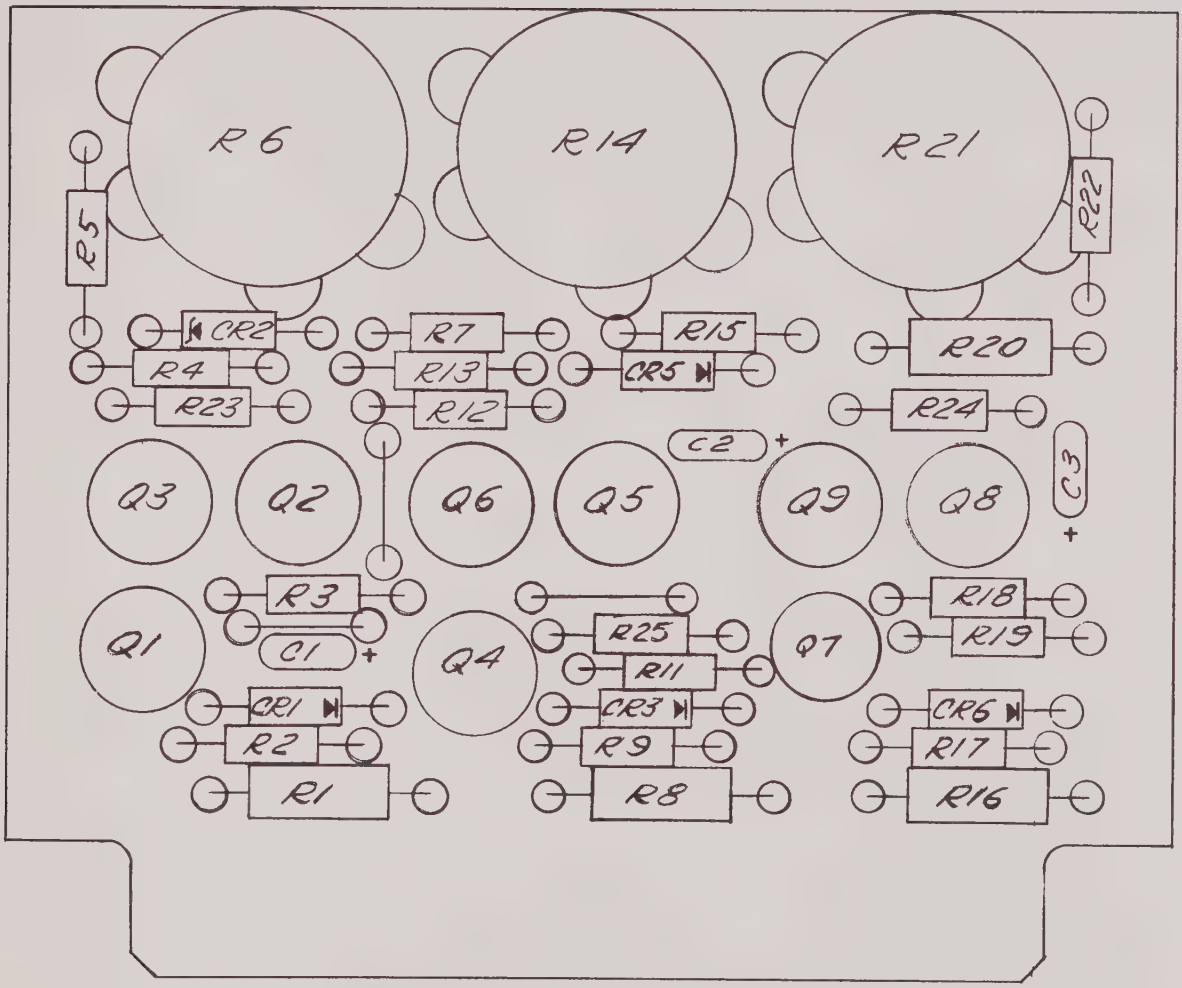
Input Amplifier P.C. Board Component Layout



DCU P.C. Board Component Layout

Models 6013, 14, 15
C 426102-Rev. A
August 1965

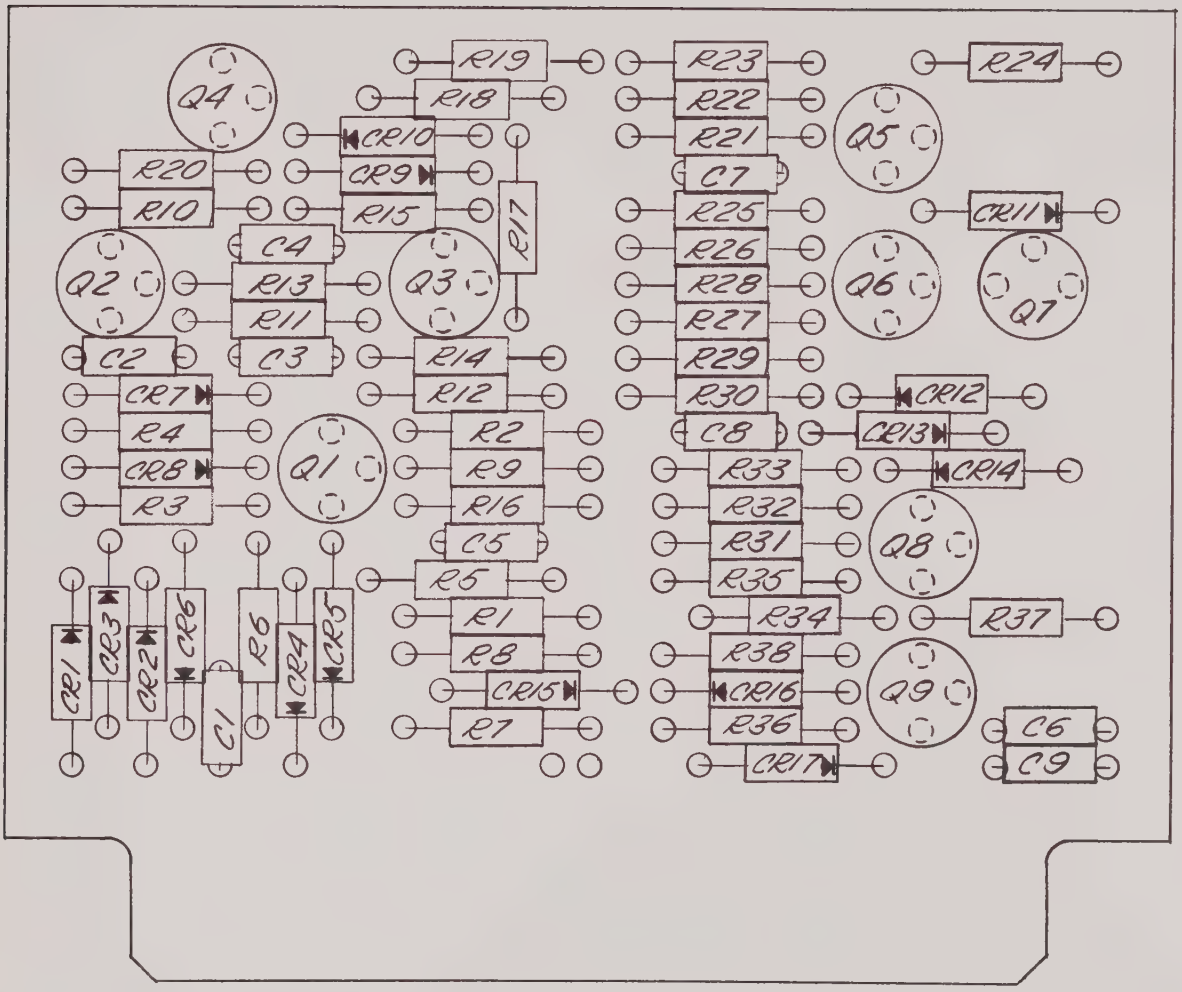
Beckman



Regulator P.C. Board Component Layout

Models 6003, 04, 05;
6013, 14, 15
C 423795-Rev. D
August 1965

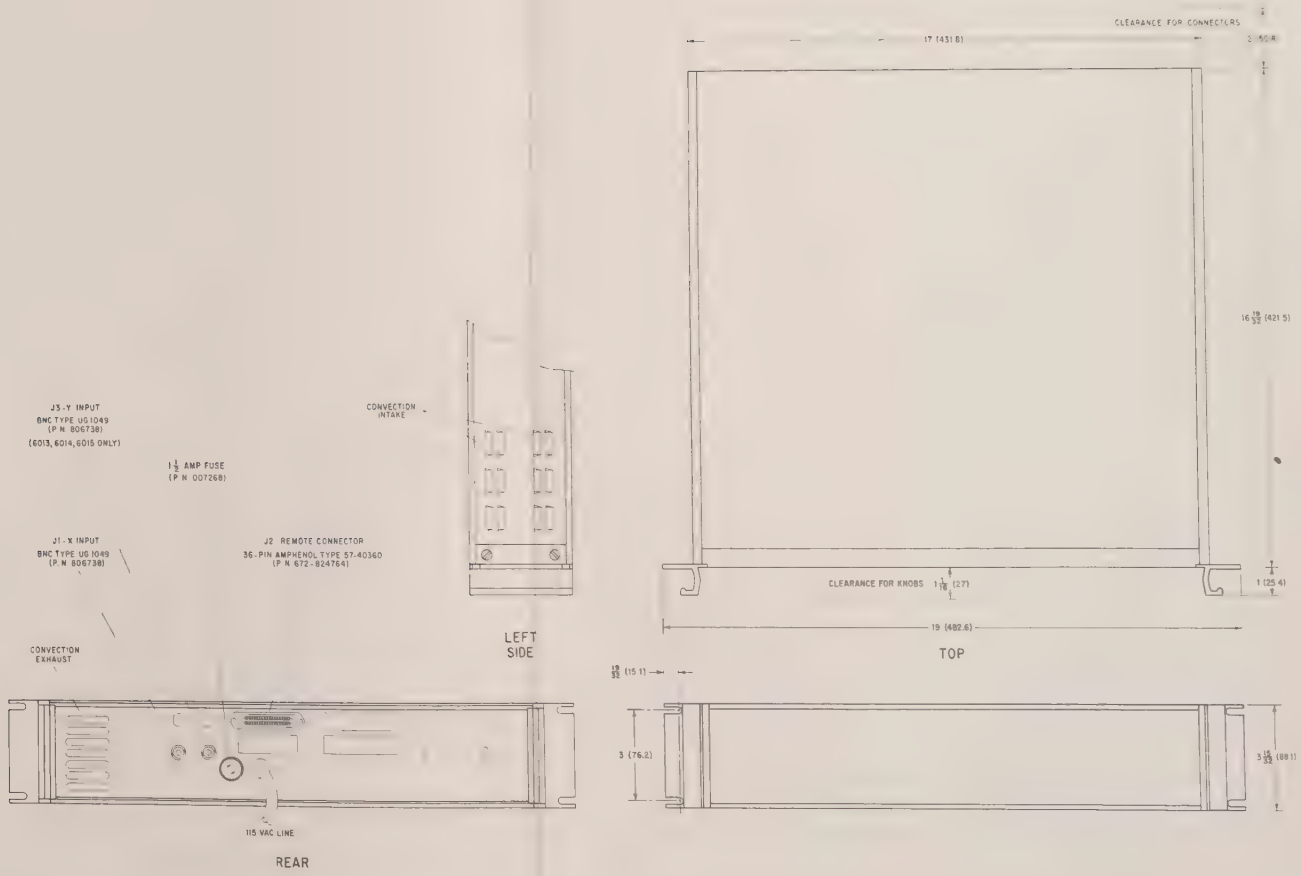
Beckman®



Preset P.C. Board Component Layout

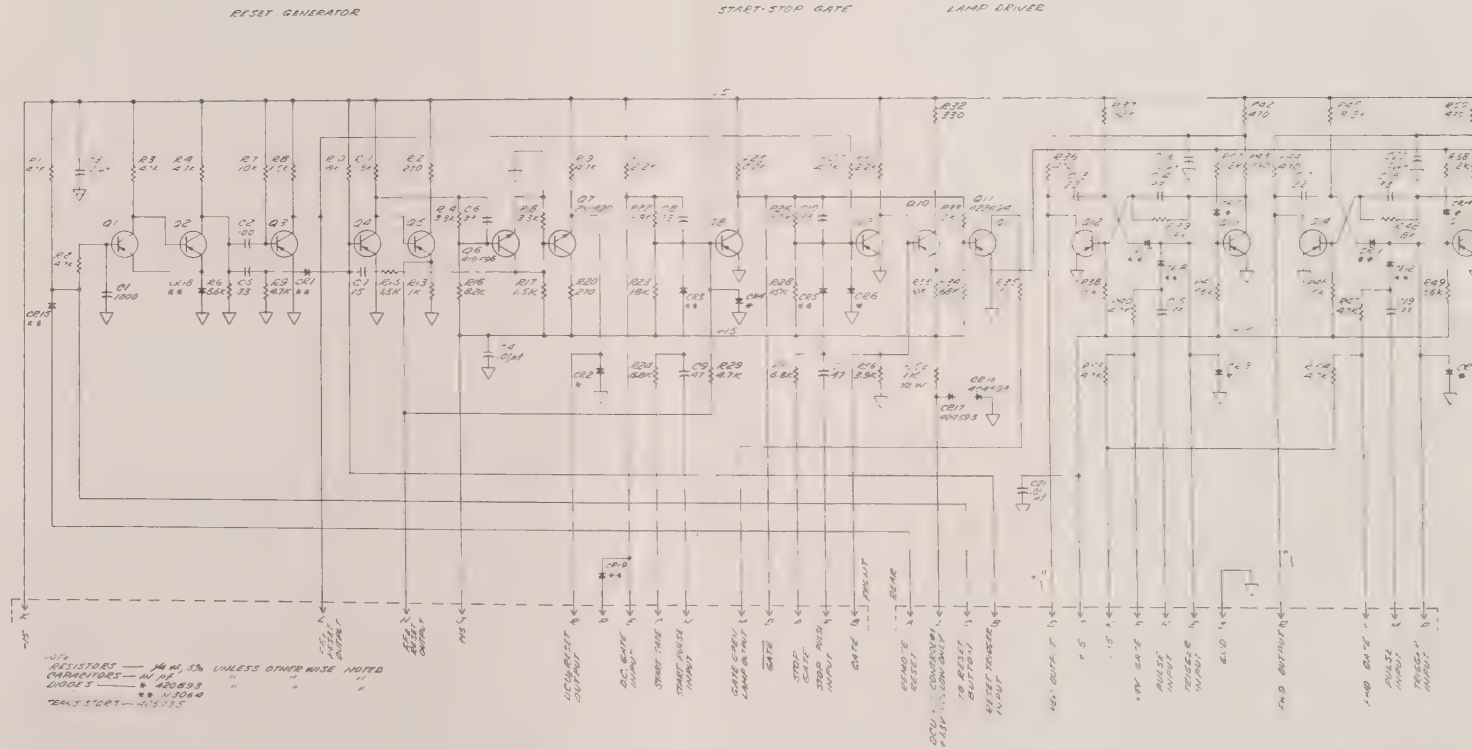
Beckman®

OUTLINE DRAWING

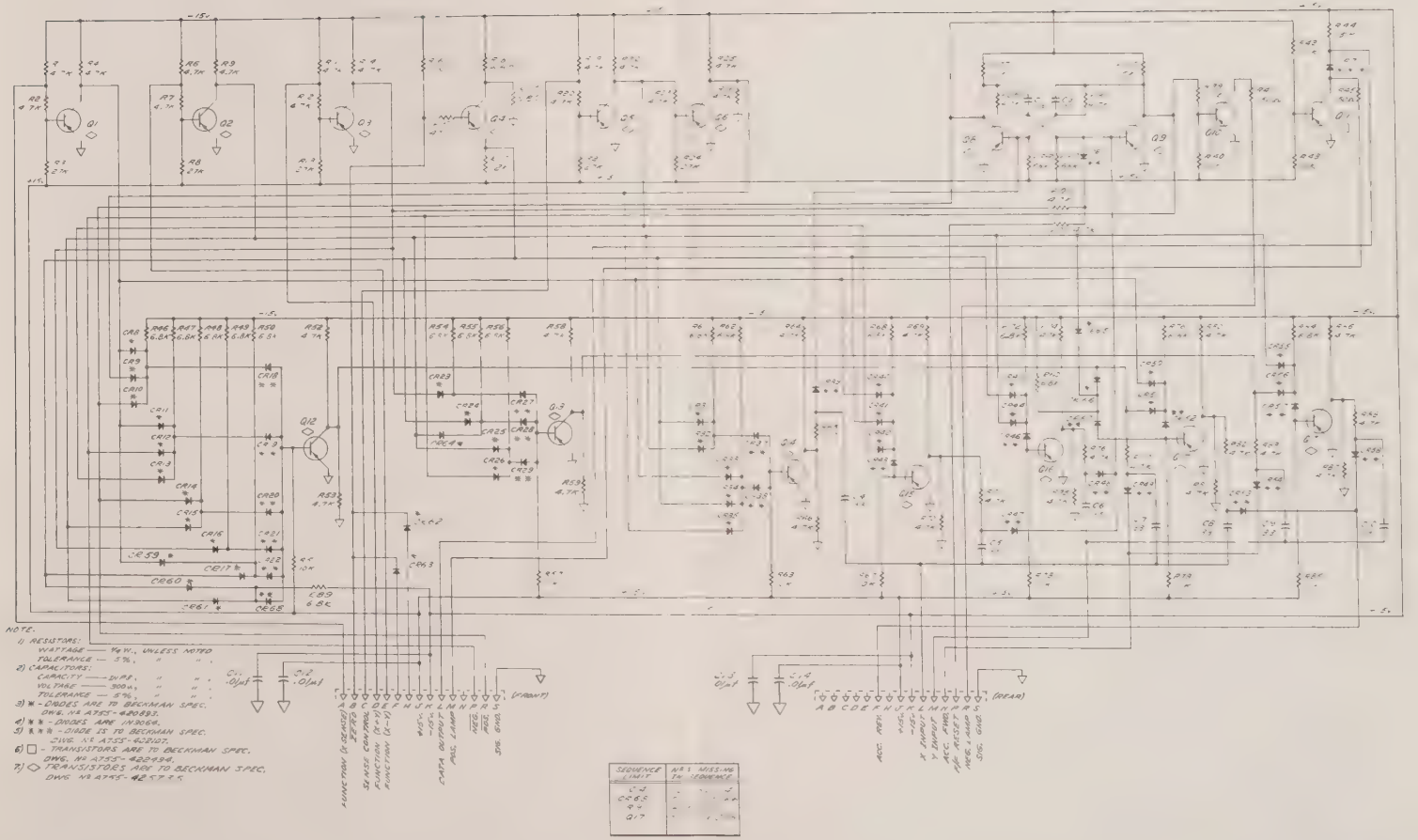


Models 6003, 04, 0
6013 , 14 ,
8"=C Rack Mount
August 1965

Beckman

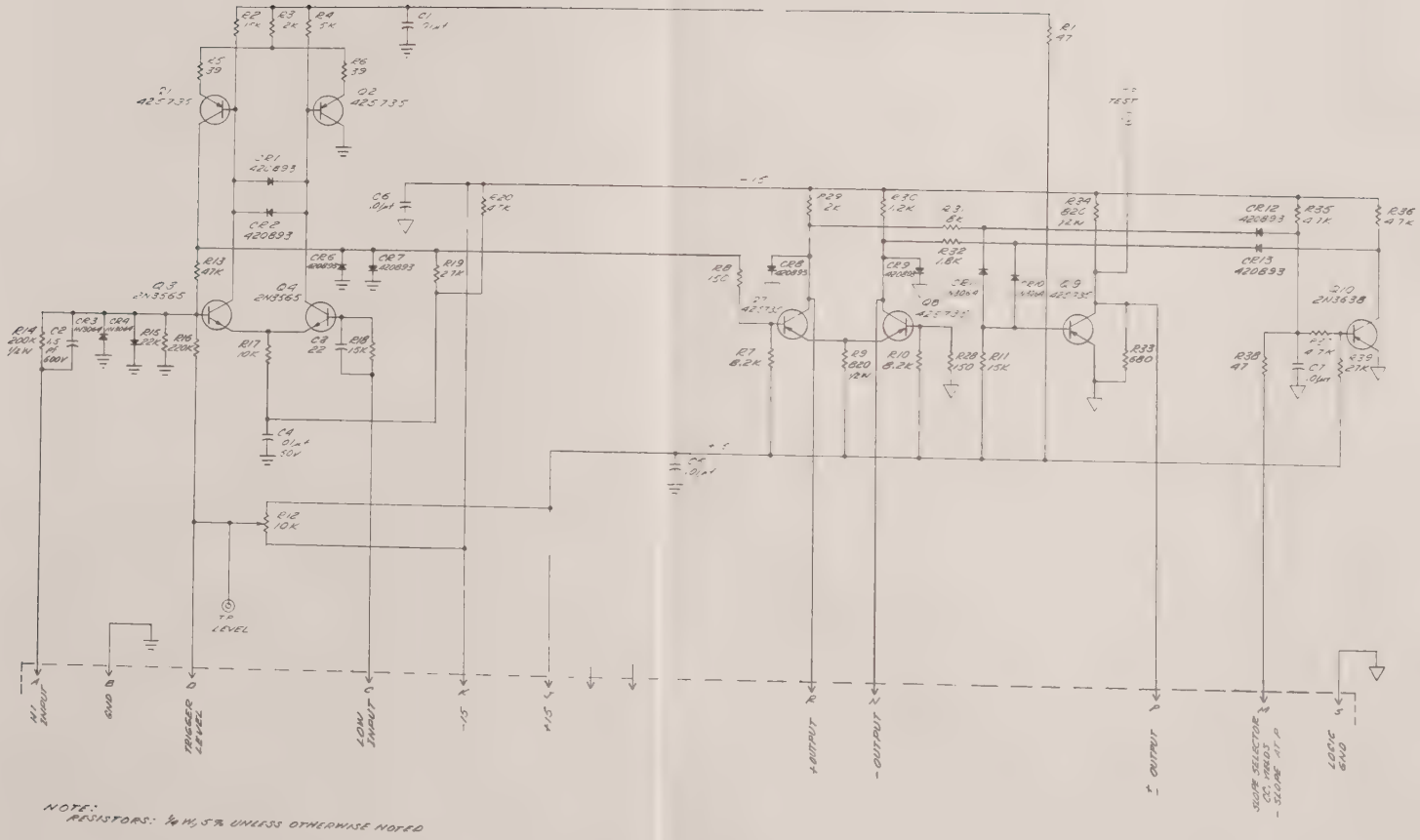


Models 6003, 04, 6013, 14
D425094-Rev. B
August 1965
Beckman


NOTE:
1) RESISTORS:
WATTAGE — ¼ W., UNLESS NOTED
TOLERANCE — 5%, " " ",
2) CAPACITORS:
CAPACITY — 1MFD, " " ",
VOLTAGE — 300 V., " " ",
TOLERANCE — 5%, " " ",
3) ✱ - DIODES ARE TO BECKMAN SPEC.
DWG. NR A755-420893.
4) ✱✱ - DIODES ARE IN3064.
5) ✱✱✱ - DIODE IS TO BECKMAN SPEC.
DWG. NR A755-423107.
6) □ - TRANSISTORS ARE TO BECKMAN SPEC.
DWG. NR A755-422898.
7) ◇ TRANSISTORS ARE TO BECKMAN SPEC.
DWG. NR A755-42557-5.
SEQUENCE LIMIT
NR 1 MISSING TO SEQUENCE
(FRONT)
(REAR)

Beckman

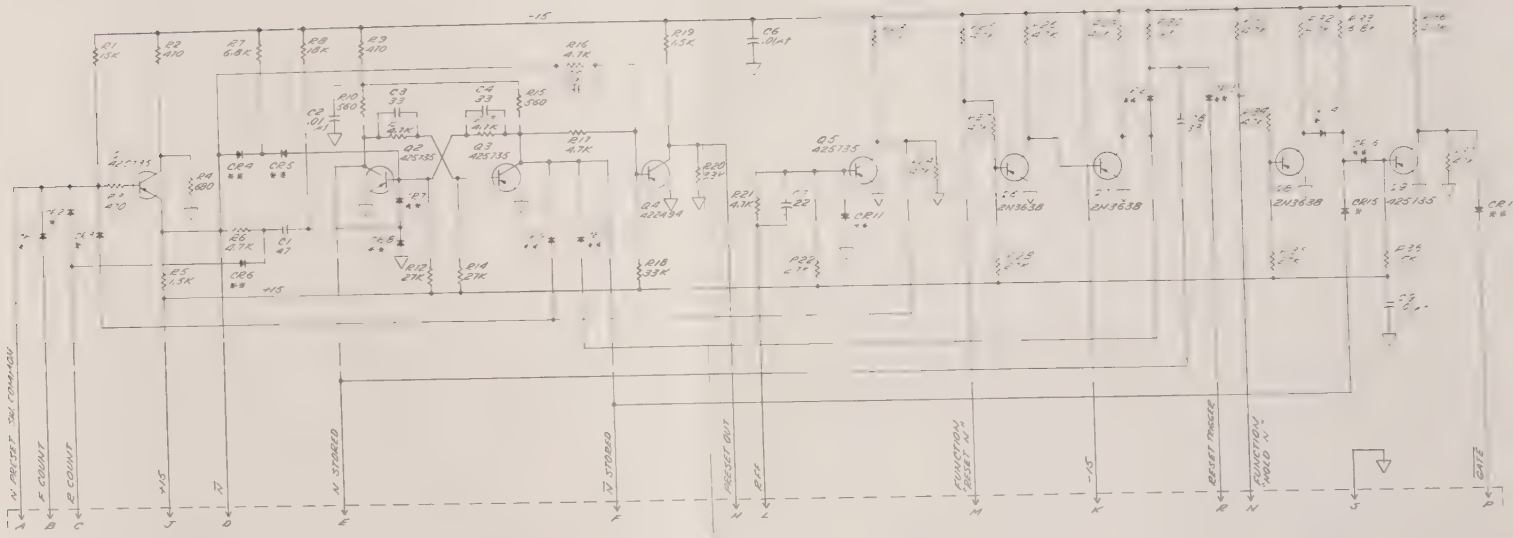
INPUT AMPLIFIER
SCHEMATIC DIAGRAM



Models 6003, 04, 05, 6013, 14, 15
D425640-Rev. B
August 1965

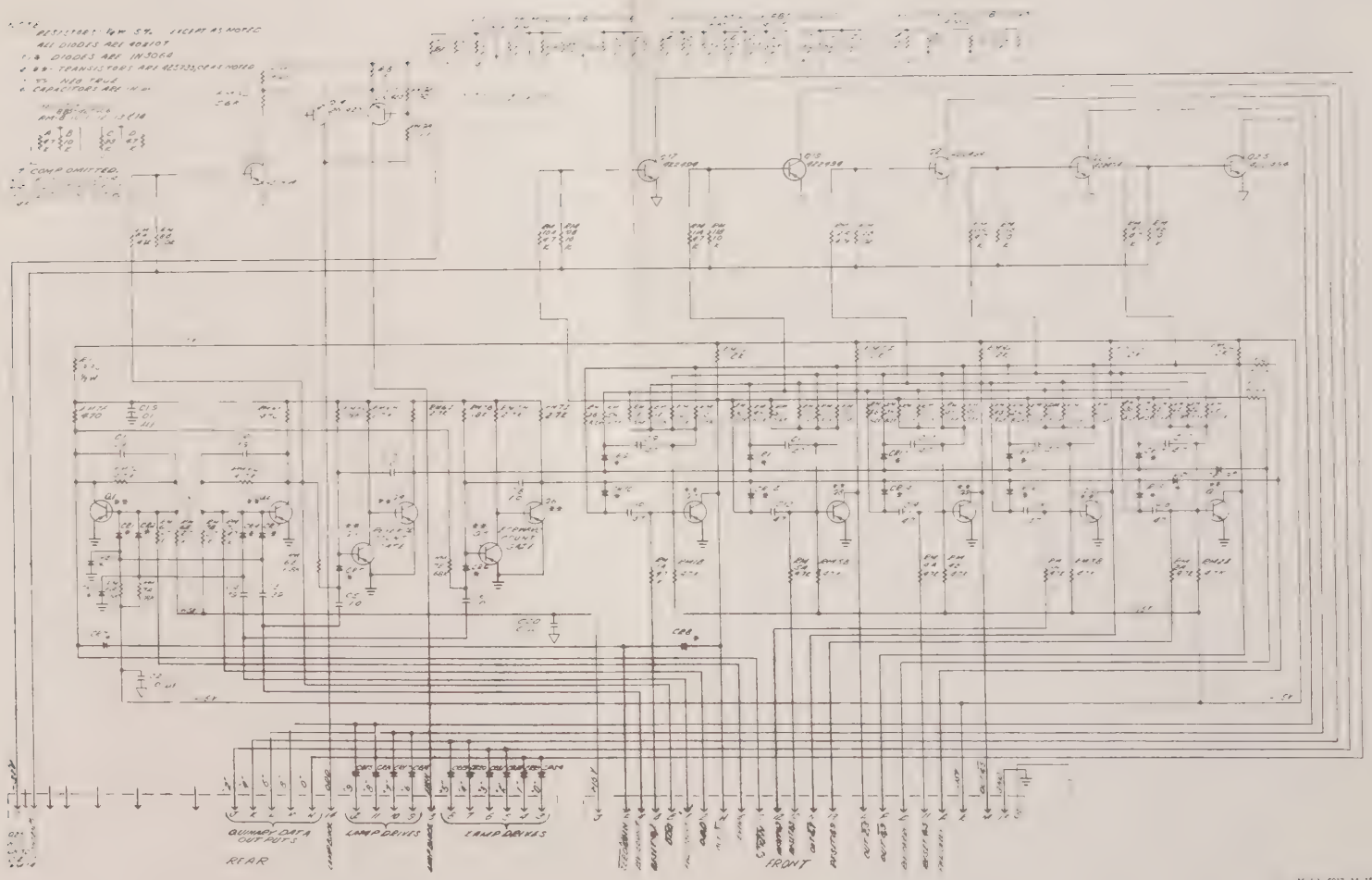
Beckman

PRESET
SCHEMATIC DIAGRAM

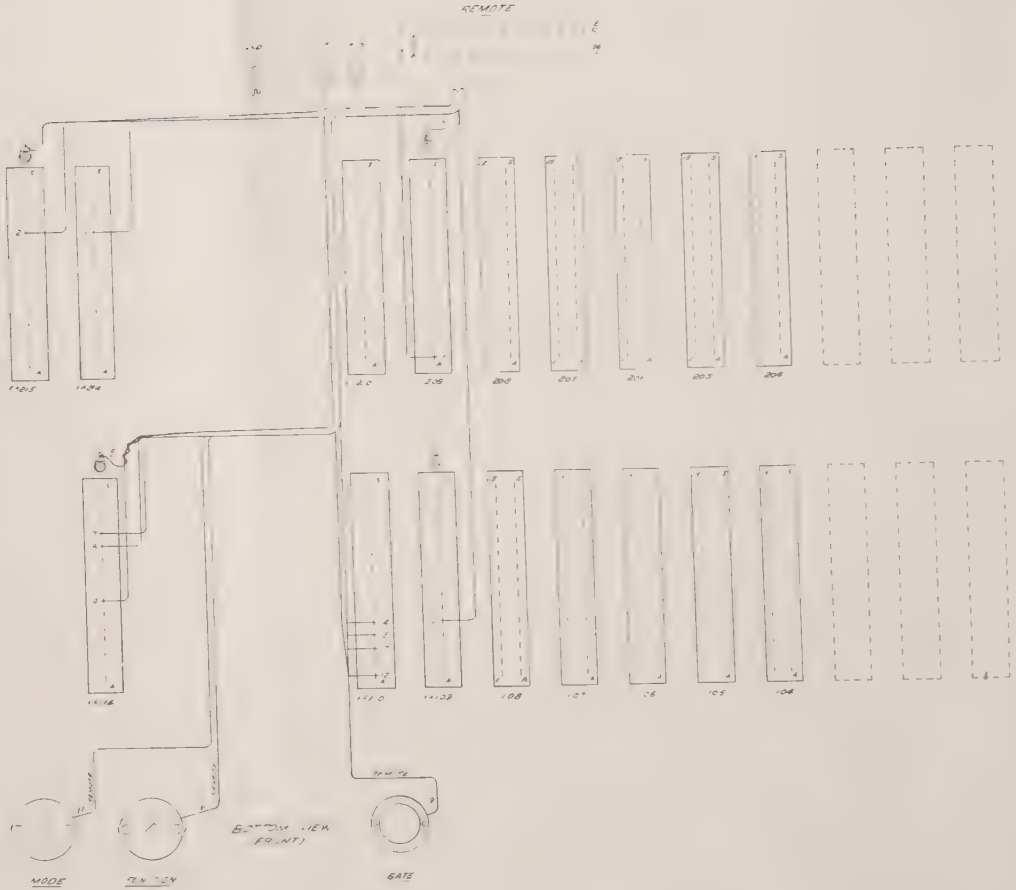


NOTES:
RESISTORS —— ¼W, 5% UNLESS OTHERWISE NOTED.
CAPACITORS —— IN pf " " "
DIODES * —— 1N3064
** —— 1N3600

Beckman


QUINARY DATA OUTPUTS
REAR
LAMP DRIVES
LAMP DRIVES
FRONT

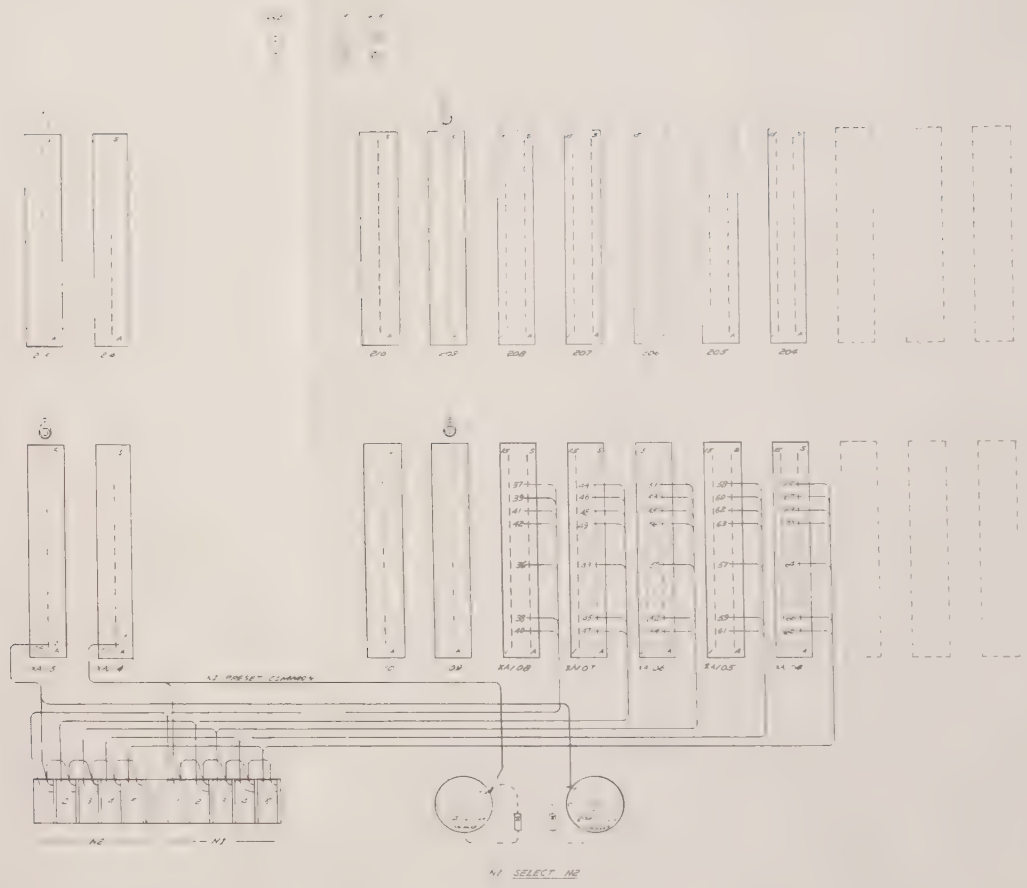
MODEL 6014
PRESET SWITCH
WIRING DIAGRAM



Model 6014
D-426123-Rev. A
August 1965

Beckman®

MODEL 6015
PRESET SWITCH
WIRING DIAGRAM



Model 6015
D476342-Rev. A
August 1968

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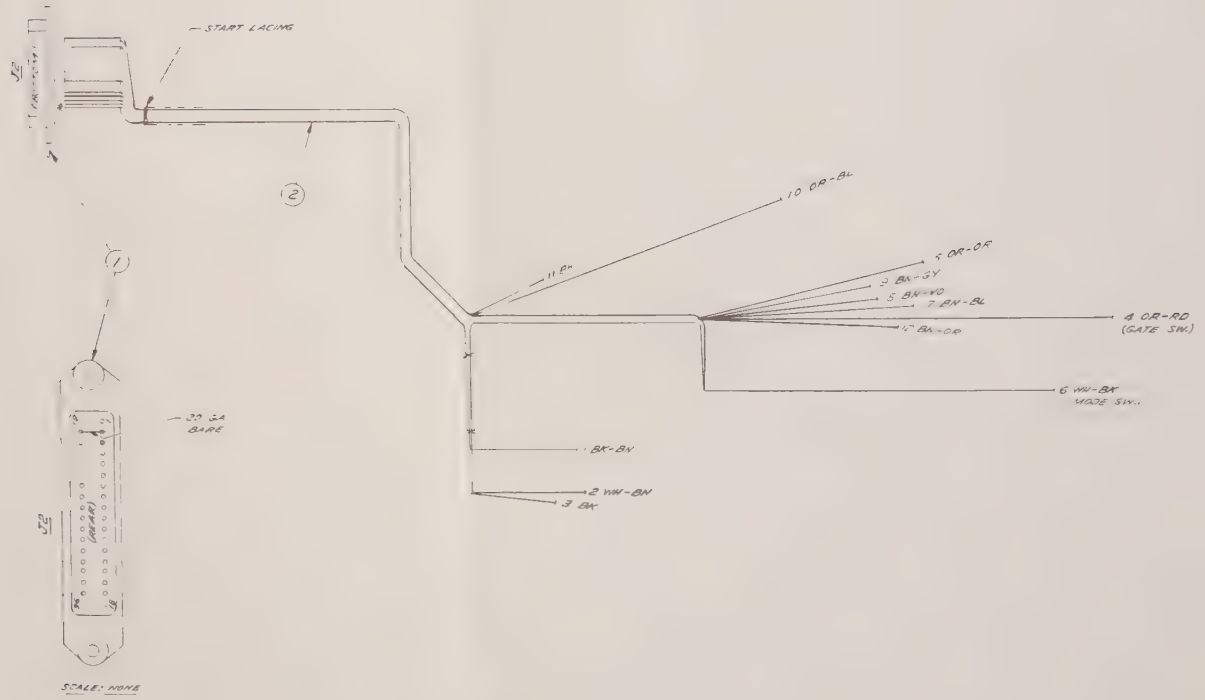
MODEL 6013
REMOTE CONNECTOR
WIRING DIAGRAM



Model 6013
C 425863-Rev. A
August 1965

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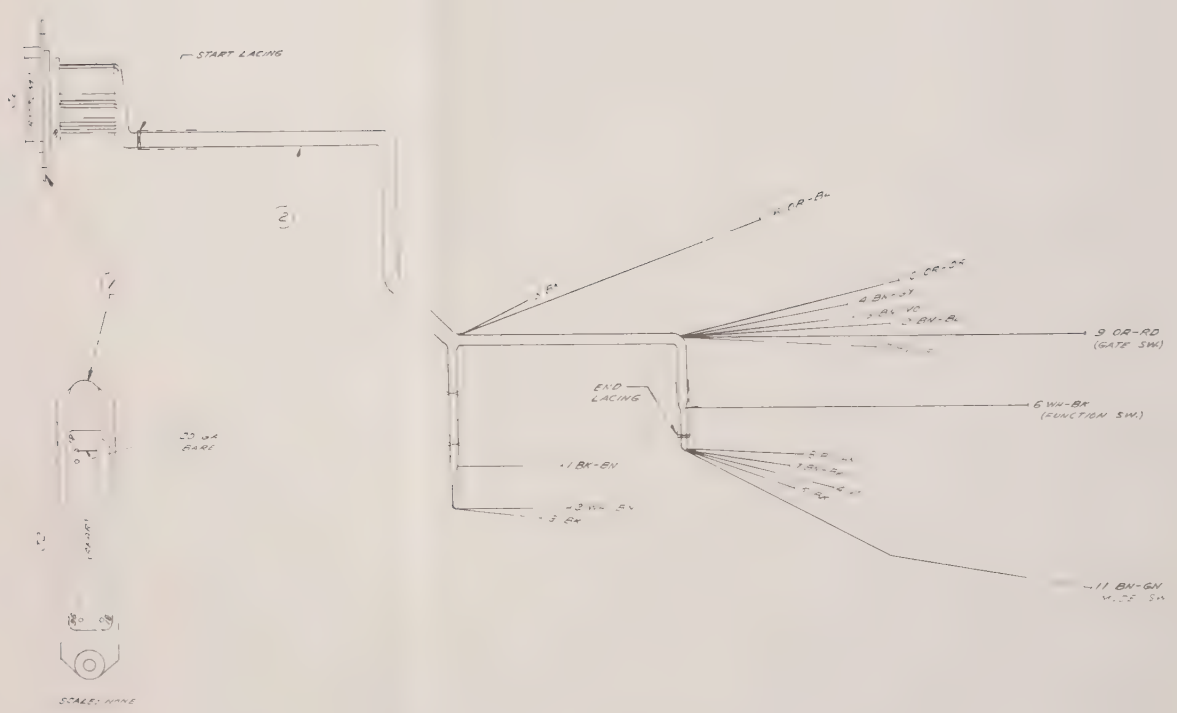
MODEL 6014
REMOTE CONNECTOR
WIRING DIAGRAM



Model 6014
C 426122-Rev. A
Printed 1965

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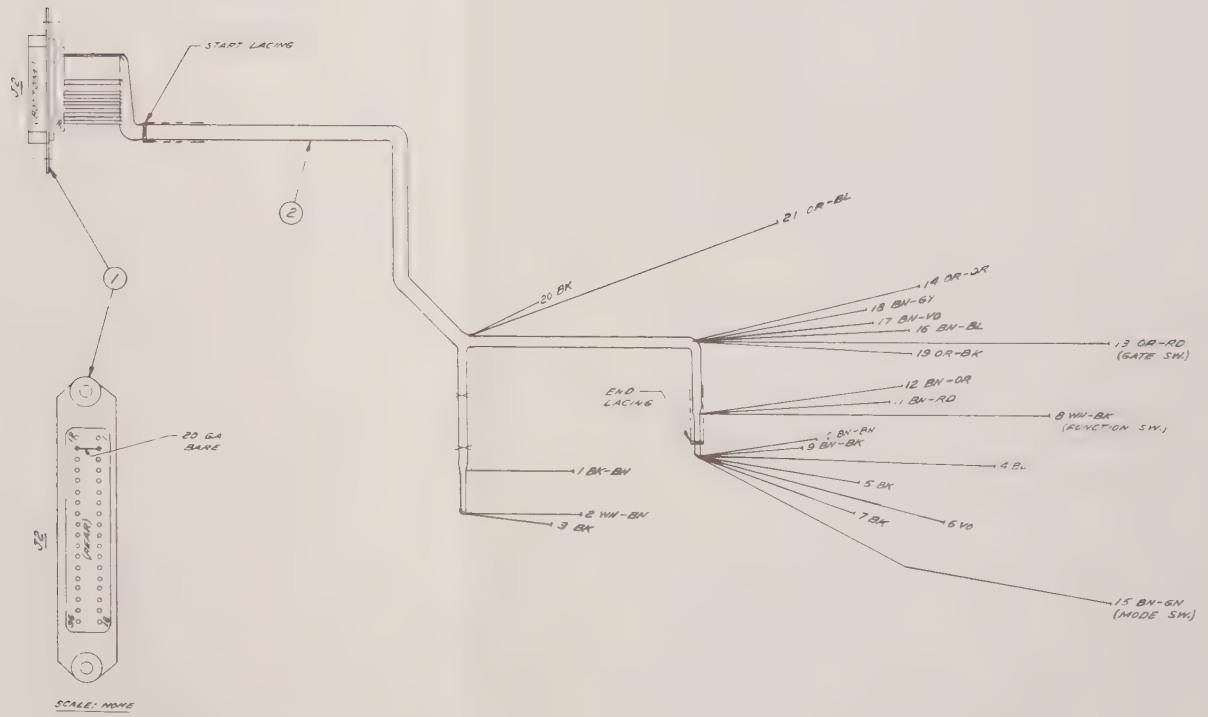
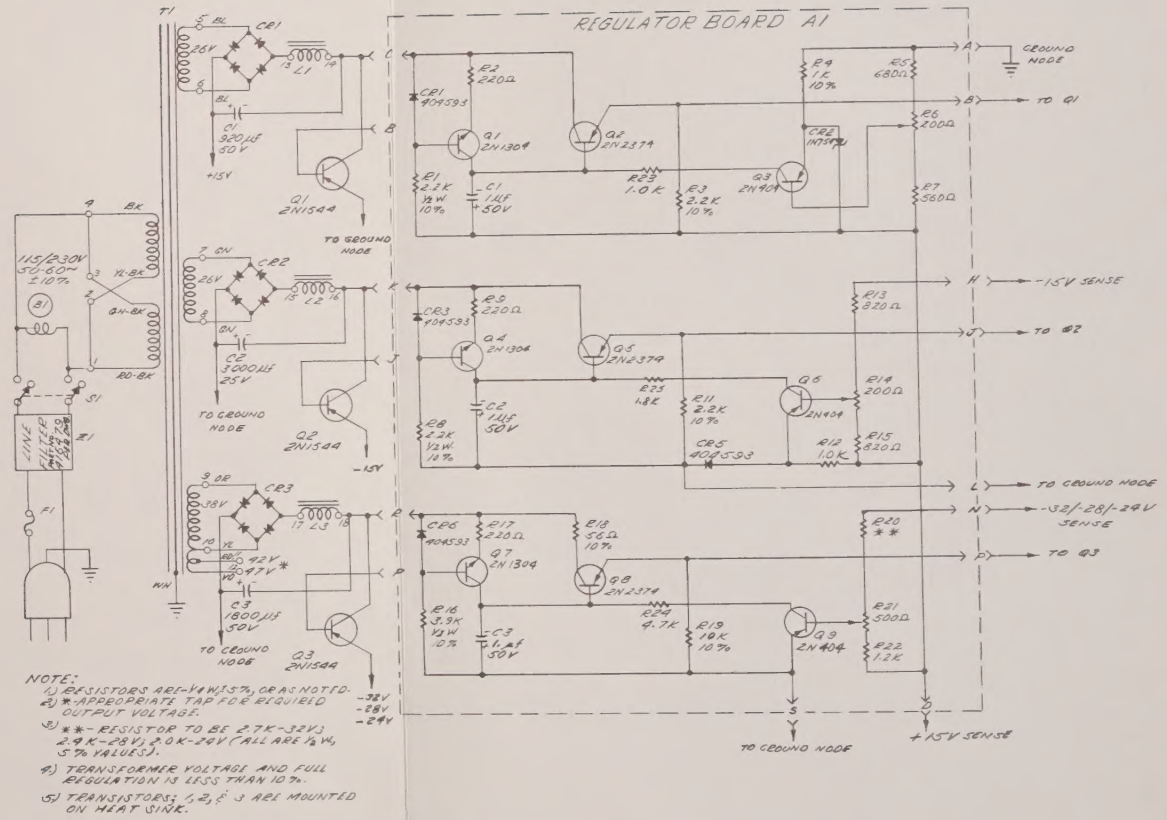
MODEL 6015
REMOTE CONNECTOR
WIRING DIAGRAM



Beckman



NOTE:
1) RESISTORS ARE ½W, 5%, OR AS NOTED.
2) *-APPROPRIATE TAP FOR REQUIRED OUTPUT VOLTAGE.
3) **-RESISTOR TO BE 2.7K-32V, 2.9K-28V, 3.0K-24V (ALL ARE ½W, 5% VALUES).
4) TRANSFORMER VOLTAGE AND FULL REGULATION IS LESS THAN 10%.
5) TRANSISTORS 1, 2, & 3 ARE MOUNTED ON HEAT SINK.

Models 6003, 6
6013, 1
C 423573-Rev. D
August 196

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